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NATIONAL GEOGRAPHIC

A man wearing a white turban and a white robe is riding a dark horse. He is holding the reins and looking towards the camera. The horse is dark brown or black. The background is a hazy, sandy desert landscape. The overall tone is warm and golden.

AFRICA'S RAGGED EDGE

JOURNEY INTO
THE SAHEL

Designs From Nature 68
Last Ride for Rickshaws? 92
Hawaii's Wild Nā Pali Coast 106
Chimps on the Hunt 124





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NATIONAL GEOGRAPHIC

APRIL 2008 • VOL. 213 • NO. 4

A Fongoli male chimp dashes along the ground, chasing another male and pant-hooting—one of many vocalizations common among these primates. Story on page 124.



PHOTO: FRANS LANTING

Features

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| The Sahel | 34 | The vast swath of sub-Saharan savanna is a world of unseen lines. Crossing one of them landed the writer in a Sudanese jail.
BY PAUL SALOPEK PHOTOGRAPHS BY PASCAL MAITRE |
| Biomimetics | 68 | Burs on a dog's coat led to the invention of Velcro. That's an example of biomimetics—the young science of adapting designs from nature to solve modern problems. Now it may be coming of age.
BY TOM MUELLER PHOTOGRAPHS BY ROBERT CLARK |
| India's Rickshaws | 92 | The city of Kolkata has a love-hate relationship with its rickshaws. Are they a symbol of exploitation? Or just a handy way to get around?
BY CALVIN TRILLIN PHOTOGRAPHS BY AMI VITALE |
| Nā Pali Coast | 106 | Golden beaches and soaring cliffs make this rugged edge of Hawaii a paradise on Earth. But tourists and trash are taking a toll.
BY JOEL K. BOURNE, JR.
PHOTOGRAPHS BY DIANE COOK AND LEN JENSHEL |
| Almost Human | 124 | The Fongoli chimps of Senegal will break off a branch, sharpen it with their teeth, and use it to hunt bush babies. That's just one of the recent discoveries that underscore the ape-human connection.
BY MARY ROACH PHOTOGRAPHS BY FRANS LANTING |

COVER Turbaned riders converge on Abéché, one of Chad's largest cities, for a popular horse race in July. **PHOTO BY PASCAL MAITRE**

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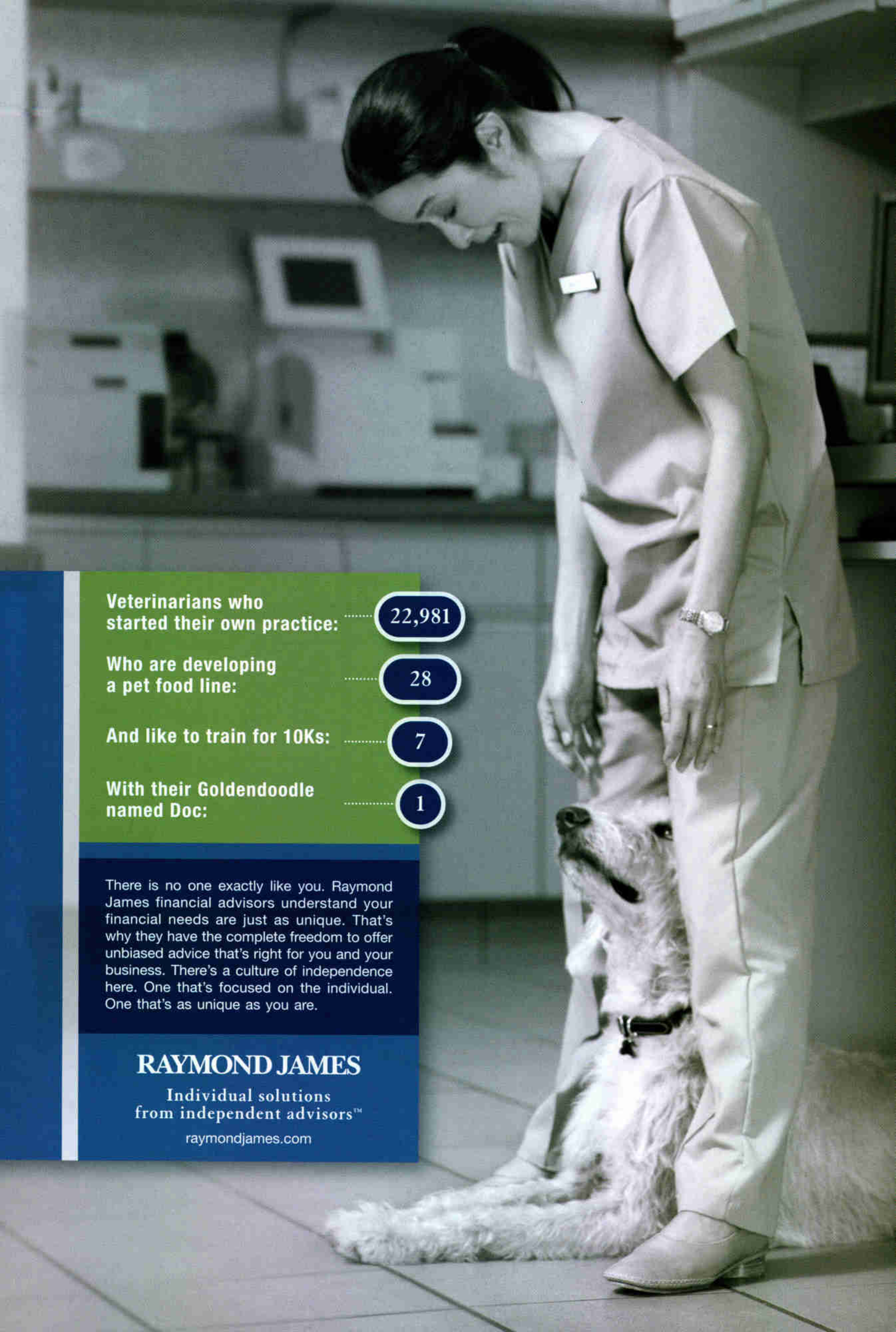
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Veterinarians who started their own practice: 22,981

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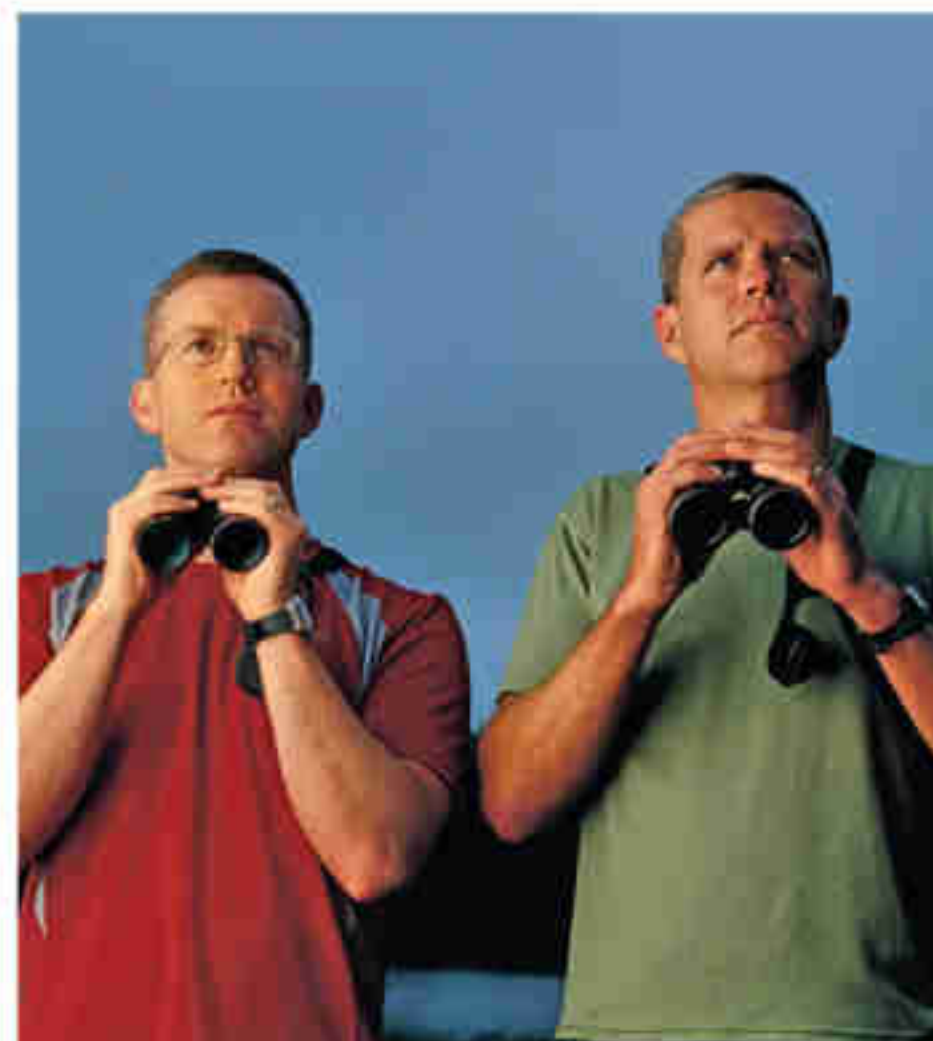
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Your Shot



Designer Mice



Bird Blitz

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On the Web

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A novice Tibetan monk, a dreamy Finnish waterfall, a bug that looks like... Elvis? Each day, *National Geographic* photo editors select an entrancing photo for Our Shot.

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EDITOR'S NOTE

I'm in Khartoum, Sudan, in a shabby hotel room with Idriss Anu and Daoud Hari. Their eyes are wide with fear. They want to be anywhere but here. Idriss is a driver and Daoud, an interpreter-guide. The two have just spent five weeks imprisoned in Darfur with Paul Salopek—the writer who hired them while on assignment for *National Geographic*—because they illegally crossed the border from Chad to Sudan. After intense negotiations, all were released from jail; now Paul is on his way back to the United States. But what about Idriss and Daoud? I've promised Paul I'll get them home safely,



Daoud Hari (left) and Paul Salopek (center) were imprisoned in Sudan.

but it won't be easy. The Sudanese rebels who arrested them confiscated their identity papers. A U.S. Embassy official explains that a diplomat from Chad will arrive to help with the papers. We'll need more than that, I think. We'll need a miracle. That miracle appears in the form of dedicated diplomats from Chad and the U.S. Embassy. Two days later Idriss and Daoud fly home.

Paul took a risk when he crossed Sudan's border. He paid dearly. He didn't want to break the law, but felt there was no other way to tell this story, because the Sudanese authorities keep Darfur and its war off-limits to journalists. Those who help and guide us in dangerous, unfamiliar places are the often unsung heroes behind the work of any writer or photographer. Idriss and Daoud also took a risk and paid the price. They, too, wanted the story told.

PEOPLE BEHIND THE STORIES

■ **Mary Roach** Among the savanna-woodland chimpanzees of eastern Senegal, where she was reporting "Almost Human," Roach got an unlikely lesson in angling. "We kept watching the chimps termite fish," she says, describing how the animals would casually dip vines into low mounds, then gently pull them up laden with supper. "They made it look really easy. When we actually tried it though, it was impossible. I felt completely incompetent." Trying to catch dinner was only half the fun. On a dare, Roach tasted the termites. "They had huge pincers. Ugh!"



■ **Joel K. Bourne, Jr.** Hundreds of feet above the sea on Hawaii's Kalalau Trail, *Geographic* contributing writer Bourne ran into a man clad only in running shorts. Bourne was working on this issue's "Fortress Coast," the man on an eroded section of the trail with a pickax. The man was a former marine who'd been living there for months, repairing the trail and helping injured hikers. The two chatted on the cliff edge as tour helicopters buzzed past and tour boats motored by below, making it the most remote place with the least solitude on the entire island. As they parted, Bourne thanked the man for his trail work. The man shrugged, said, "Somebody's got to do it," and went back to his labors.





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California Channel Islands Fox (*Urocyon littoralis*)

Size: Head and body length, 48 - 50 cm (18.9 - 19.7 inches); shoulder height, 12 - 15 cm (4.7 - 5.9 inches); tail, 11 - 29 cm (4.3 - 11.4 inches) **Weight:** 1.3 - 2.8 kg (2.9 - 6.2 lbs) **Habitat:** Grassland, scrub, chaparral, woodland and dune on the six largest Channel Islands **Surviving number:** Estimated at fewer than 2,000



Photographed by Larry Ulrich

WILDLIFE AS CANON SEES IT

Some neighbors are more neighborly than others. The California Channel Islands fox avoids the golden eagle, which is always looking to make a meal of it, but welcomes the seafood-favoring bald eagle. When bald eagle populations are healthy, the non-native golden eagle tends to stay away from their territory, which is a big plus for the little fox. But when bald eagle populations diminish, the fox becomes a target of the golden eagle and its

populations are decimated in turn. The smallest canid in North America mates for life but, faced with the very deadly threats of predation and disease, who knows how long that life will last?

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December 2007 *"Bethlehem 2007 A.D." touched a nerve with readers. "It amazes me that in this day and age there is still violence related to religious beliefs," wrote Steve Michalski of Silver Spring, Maryland. "Walls, barbed wire, bombs, and guns have nothing to do with truth. A piece of land has nothing to do with what is truly holy."*

➤ Comment on April stories at ngm.com.

Bethlehem 2007 A.D.

We have just returned from traveling in the West Bank and Israel, spending the night with families in Bethlehem and Jenin and visiting Jerusalem, Ramallah, Hebron, Tel Aviv, and Sederot. Our group, including Christians and Jews, felt safe at all times. Everyone welcomed us warmly, thanked us for coming, and asked us to tell people at home about their lives. Perhaps the most important thing we outside the Holy Land can do to further a just peace is to go and see the situation firsthand and simply be present with those working so hard for peace. There are many such courageous people on both sides.

JUDY AND MICHAEL WHITE
Ashland, Ohio

Until Palestinians come to terms with the reality of an Israel that is here to stay and

start looking to a future they can build instead of trying to destroy what others have created from nothing, there will be no peace. It is time for the Palestinians to produce some honest, forward-thinking leaders to pull them out of their swamp of irrational hatred and into the 21st century. The ball is clearly in their court.

PAULA KLEIN
Indian Wells, California

What a shameful legacy for Israel to collectively punish civilians by locking them behind a three-story-high wall, separating them from jobs and family lands. Or is it the Israelis who are locked in? Time will tell.

JUDY BUETTNER
Haiku, Hawaii

Two important points must be made about your article on Bethlehem. First, it is unfortunate that Bethlehem residents must be closed in due to Israel's security wall. However, until they choose to deal with the terrorists in their midst, their difficulties are preferable to the possibility of my child being blown up on a bus. Second, it is astonishing that the author never asked the obvious question: If life is so difficult in the overwhelmingly Muslim city of Bethlehem, why

are only the Christians leaving? What we're hearing is that militant Islamists are making life increasingly unbearable for the Christian "infidels" there. In other words, just as they are pledged to make the land of Israel *Judenrein*, so too are they striving to make Bethlehem *Christianrein*.

GILA MANOLSON
Jerusalem, Israel

The only way to achieve a tolerant community is by all sides striving to integrate with each other, not necessarily religiously or culturally, but in schools, workplaces, and in every aspect of daily life. I wish more than anything that a leader from each group will emerge and be able to achieve peace between the truly great people of all sides in this land.

PAUL JANEWAY
Woodland Hills, California

While you make a point of the separation fence in Israel, it is hardly the only one. There are many in the world, and I would like to point out that the United States has a fence just like the one in Israel, on the border with Mexico.

GABRIEL R. STUART-SIKOWITZ
Gaithersburg, Maryland

This article confirms my belief that religion—not money—is the root of all evil. That Jews and Muslims kill each other with the excuse that "My God is better than your God" also reminds me of the German proverb "Against man's stupidity even the gods fight in vain." Thank God I am an atheist!

CARLOS MUÑOZ
New York, New York

Write, Email, Fax

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LETTERS

On the Wings of the Albatross

I, too, admire many qualities of the albatross. But it is hardly “fueled by clean, self-renewing, zero-emissions energy,” so rhapsodically described in your article. The albatross emits gases just as an SUV does, and the excrement issuing from its “tailpipe” is hardly a clean by-product of its metabolism. Birds are among the biggest polluters of land, water, and buildings. And the so-called self-renewing part of the equation is accomplished at the expense of other species eaten by the albatross.

JOSEPH LEASER
Oceanside, California

When I got to pages 86-7, I was fascinated with the resemblance of the head-on view of the

albatross to the Concorde airplane. There is something symbolic in this: The albatross flew first and is still doing so, while the Concorde is extinct.

BILL LATHLEAN
Pleasanton, California

Extreme Dinosaurs

Dracorex surely qualifies as an extreme dinosaur, but we contend it is also a youthful dinosaur, a juvenile *Pachycephalosaurus*. We hypothesize that the horns and spikes on the “flat-headed” *Dracorex* erode as the dome develops with age. Some paleontologists might consider this extreme, but we observe a similar pattern in the closely related and well-known late Cretaceous *Triceratops*. Delta-shaped bones first appear in juveniles

along the edge of the skull. As *Triceratops* grows, these bony triangles erode and merge with the frill in subadults, and disappear entirely in adult skulls. The pair of dominant horns over its eyes point backward in juveniles before eroding to grow forward in subadult and adult *Triceratops*. We hypothesize that this extreme morphology enhances visual communication and signals sexual maturity in these dinosaurs.

MARK B. GOODWIN
Museum of Paleontology
University of California
Berkeley, California

JOHN R. HORNER
Museum of the Rockies
Montana State University
Bozeman, Montana



Goodwin's and Horner's hypothesis that *Dracorex* represents a juvenile *Pachycephalosaurus* was presented at the Society of Vertebrate Paleontology meeting in late October 2007, after our December feature on extreme dinosaurs had already gone to press. Regardless of its age at time of death, however, the creature merits a place in our gallery of Mesozoic oddities.

When I saw the image of the *Masiakasaurus* speeding through shallow water, my first thought was the mouth of a gharial, the crocodile-like reptile from the river Ganges. It feeds on fish and has the same protruding teeth as the creature shown in your magazine.

FRANK LENICH
Bayreuth, Germany

Are you sure you have your facts straight? That *Masiakasaurus* sure looks like one of my former bosses.

EARLE KOLBE
Alcoa, Tennessee

It surprises me that paleontologists don't ask military people about dinosaur survival tactics. The short arms of the *Carnotaurus* suggest a scavenger more than they do a perfect killing machine. If one bit me, I'd just whip my big tail around and knock him off. Modern carnivores like the African big cats use claws on long arms and big teeth for killing. One would think a multiple assortment of weapons would be needed to take down these big cattle. In the case of the duck-billed *Parasaurolophus walkeri*,

wouldn't an acoustics check of that tube be a way to check it out for hornlike noises? Musical instrument makers would probably bend over backward to help prove or disprove these claims.

JIM CHORN
Portland, Oregon

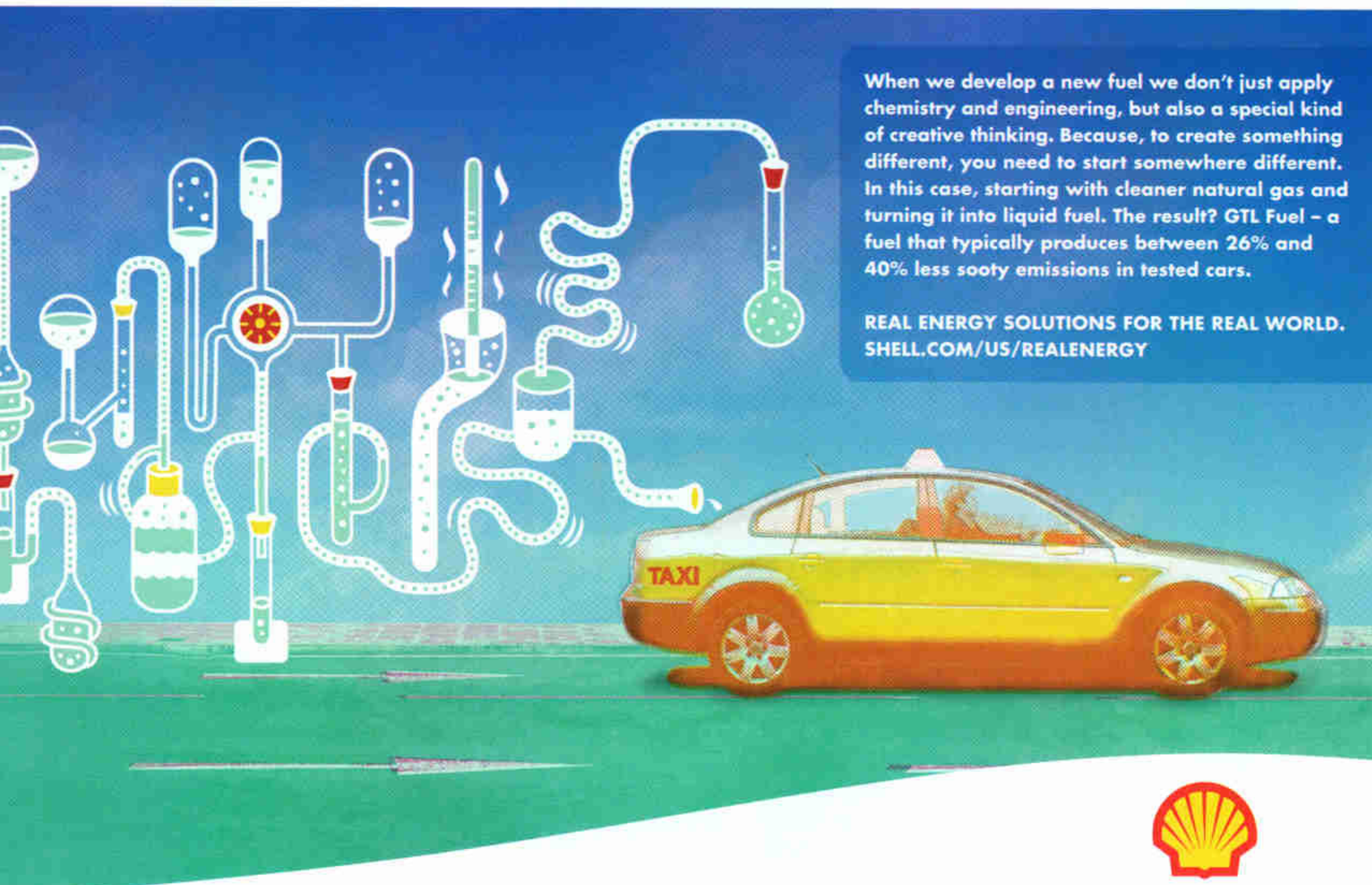
Corrections, Clarifications

December 2007

The *Styracosaurus* skull shown on page 56 should have been credited to the collection of the Canadian Museum of Nature, Ottawa.


April 2007

The Marilyn Monroe art glass bead shown on the Culture page "Unstrung History" was made by Emiko Sawamoto.



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LETTERS

21st-Century Cowboys

It's altogether fitting that the December issue should place articles on cowboys and dinosaurs side by side. If ever there was a profession that needed to slip quietly into the mists of time, it's that of the cowboy. Broad sweeps of public lands in the western United States have been set aside for cattle grazing, land that becomes eroded and destroyed because of the actions of these animals. Stands of piñon and sage are torn down. Fire-prone crested wheatgrass is planted, and vast water projects soak up the last drop of water in an already arid ecosystem. Animals such as the sage grouse and the pygmy rabbit edge closer to extinction. Cattle- and sheep-borne diseases threaten native populations of ungulates, such as bighorn sheep. I'll not even start on the impact the cattle industry has had historically on native cultures in the West. "Cowboying" is just bad news.

RICK HOBSON
Boise, Idaho

When I was six years old, I wanted to be a cowboy when I grew up. After reading your wonderful piece on 21st-century cowboys, now at 61 years of age, I realize I still haven't grown up.

DANIEL ROGG
Church Hill, Tennessee

I particularly appreciated Robert Draper's tracing of anglicized words to the original Spanish, but he missed one. On page 124 he uses the word "dallying," meaning "wrapping one's rope around the saddle horn." The full English phrase is "dally welter" and comes directly from the Spanish words *dale vuelta*, meaning "wrap around" or "give it a turn."

JAMES VASQUEZ
Ellensburg, Washington

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North America. Frederic Remington painted the likes of a cow hunter who used bullwhips to herd cattle through palmetto, saw grass, swamps, and swarms of mosquitoes. Florida cattle drives existed before the western trails of lore were established and state law fenced in free-ranging cattle. Today the Florida cowboy still thrives, making the state 11th in national beef cattle production.

MIKE DENNIS
Green Cove Springs, Florida

I read with interest your story on cowboys. I spent my young life in or around Williams Lake, so I have quite a bit of knowledge about the territory and the people who work on it. If by any chance you visit Williams Lake, I would strongly advise you not to call a cowboy a buckaroo.

WILFRED LOWDEN
Victoria, British Columbia

Your article about the simple yet satisfying life of cowboys was a heartening reminder that there remain some people who haven't got caught up in the materialism that has taken over American society. Another virtue that wasn't mentioned in the article: cowboys' freedom from having to listen to the loud cell-phone conversations that pervade everywhere from the workplace to church to even public restrooms.

BOB SOLTIS
Cleveland, Ohio

Having spent my entire 59 years in the city, I'm no expert on cowboys, but I think your article failed to note a prime attribute. I believe the essence of the American cowboy is something he/she would never discuss. It's about self-confidence and the respect of one's peers. About choosing to face adventure and adversity head-on, without whining, certain that you have what it takes to handle whatever comes along. Cowboys are the real deal.

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Glenn Losack New York, New York

A blind Haitian man minds his sleeping grandchild in San Pedro de Macorís, Dominican Republic. Photographer Glenn Losack, 53, is a practicing psychiatrist but says, "I make photography my priority."

Lisa Gonnelli Pilesgrove, New Jersey

The sky's a favorite subject for Lisa Gonnelli. When she saw this circum-horizontal arc—a colored cirrus-cloud display—she "started taking pictures. This is one of 85." Gonnelli, 44, works as a bookkeeper. Online voters named her photo their October 2007 Top Shot.





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On Time We all have our ways of marking time. As a *National Geographic* photographer, my life is measured from one story to the next. I bought my first house in Nebraska while I was on assignment shooting America's Gulf Coast. My oldest son was born in the middle of a long story about the Endangered Species Act. My daughter came along with a pack of gray wolves.

Twenty stories later, though, it's the story on Alaska's North Slope that I'll remember most. It was about the loss of wilderness and innocence—and the story during which my wife got cancer. That's the one that made time stand still.

Kathy and I met at a blues bar in college. She had long blond hair and thought I was funny. Beautiful, graceful, and patient, she has remained my muse for 24 years, despite the thousands of

times I've forced her to be photographed. She may have gotten tired of it now and then. I stopped taking pictures on the day she found that tumor in her right breast. It was the size of a hen's egg. Weirdly, it was Thanksgiving. By Christmas, the chemo had her weak and bedridden. Some days she was so sick she couldn't watch TV. One day she couldn't even talk.

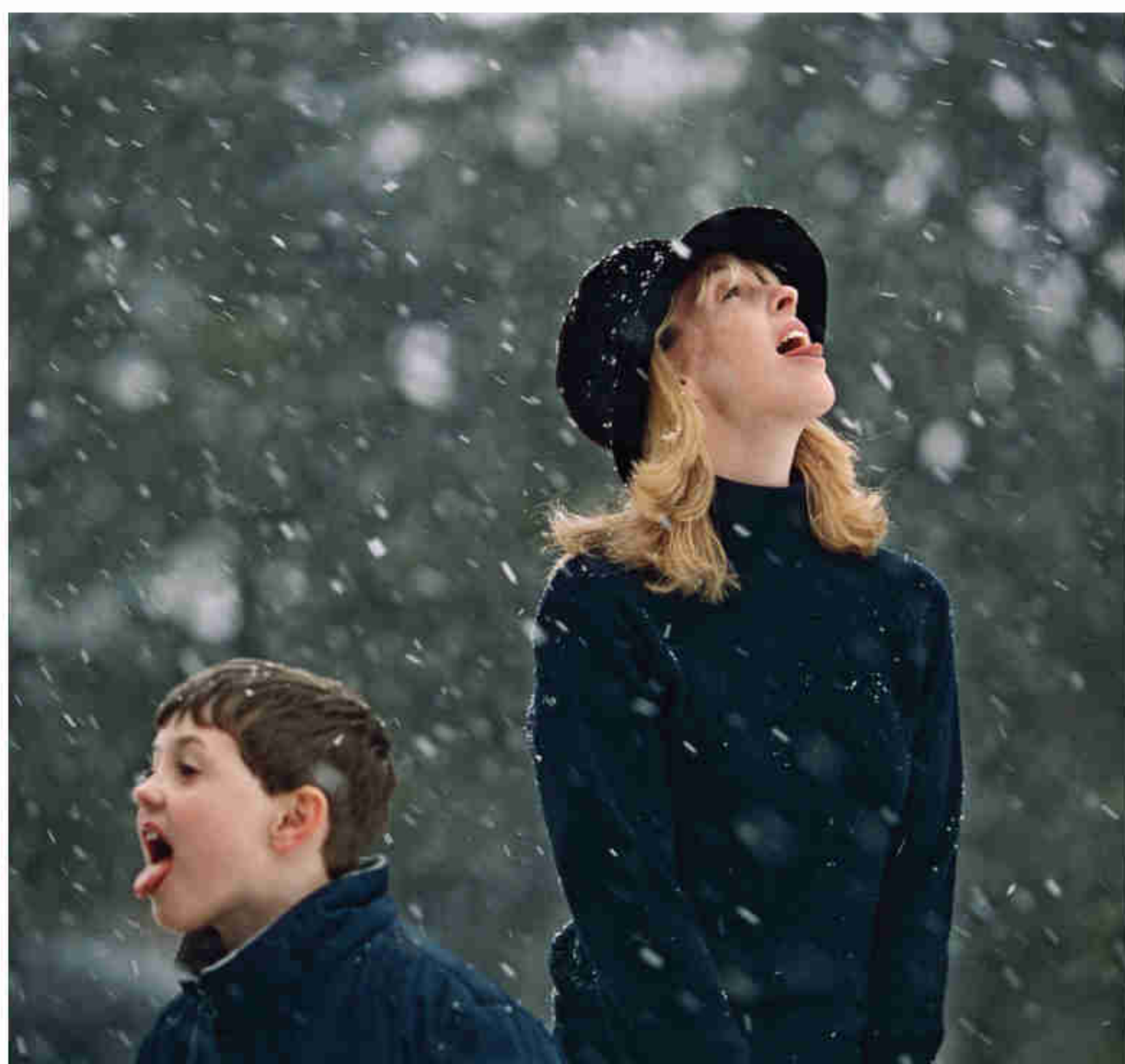
Early detection saves lives. But ours was not early. By the time you can feel it yourself, it's often bigger than the doctors want it to be.

Cancer is a thief. It steals time. Our days are already short with worry. Then comes this relentless disease, unfair as a hailstorm at harvesttime. But cancer

also has the power to transform us, for good. We learn to simplify, appreciating what we have instead of lamenting what we don't. Cancer even made me a better father. My work had made me a stranger to my three kids. But now I pay attention to what really matters. This is not a race. This is a new way of life and new way of seeing, all from one malicious lump.

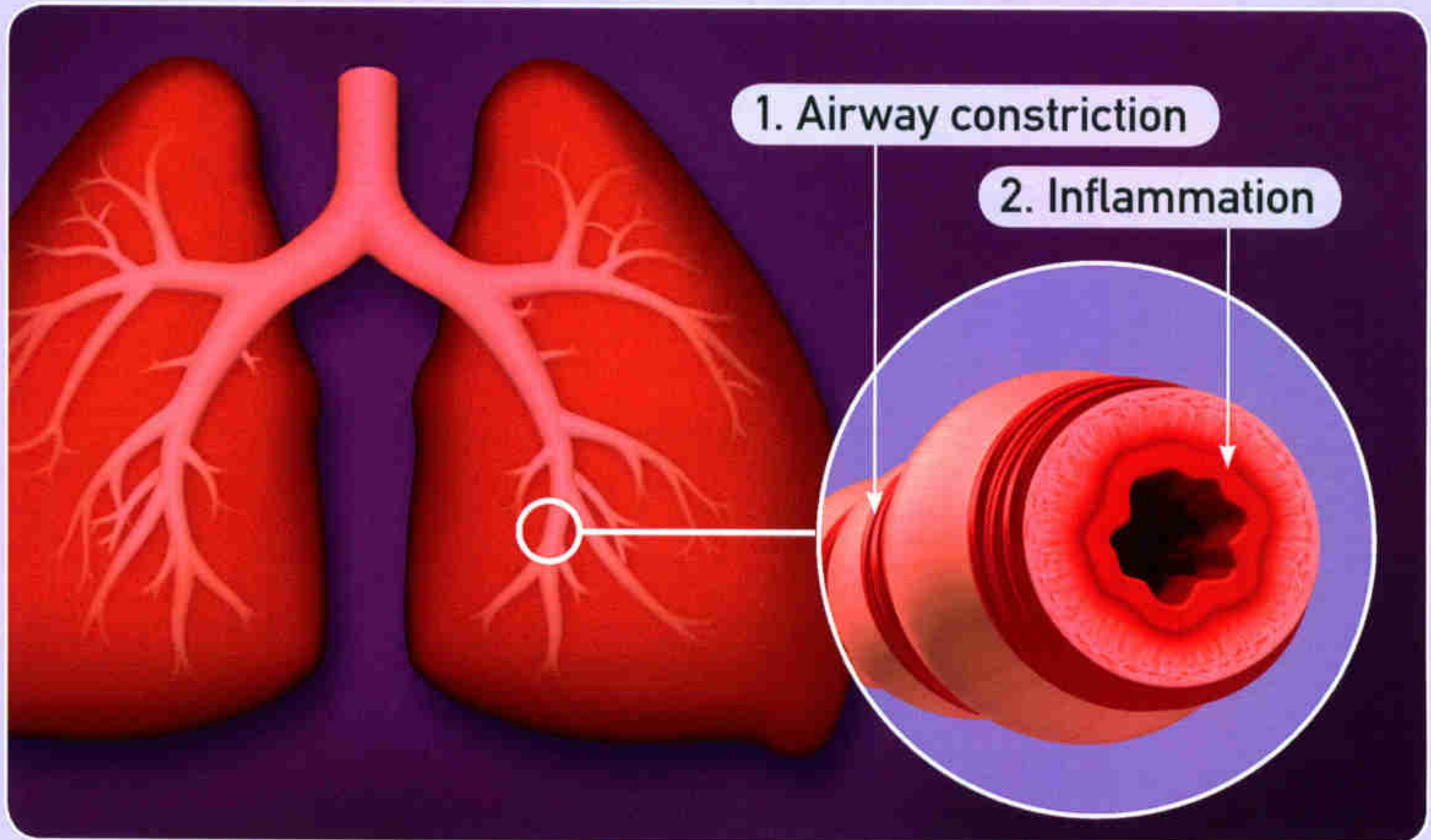
In the end each of us has so little time. We have less of it than we can possibly imagine. And even though it turns out that Kathy's cancer has not spread, and her prognosis is good, we try to make it all count now, appreciating every part of every day.

I've picked up my camera again. I watch the sky, searching for beautiful light. When winter storms come, Kathy and I gather our children and take the time to catch snowflakes on our tongues. After all, this is the good stuff. This is what we're living for.



The Sartore family—Cole and Kathy (above), Ellen, Spencer, and Joel—lives every minute to the fullest in Lincoln, Nebraska.

Asthma has two main causes. Treating both with ADVAIR[®] helps prevent symptoms.



If your symptoms keep coming back, it could be that your controller is treating only one of the main causes.



Help prevent symptoms. Treat both main causes.[™]

Ask your doctor if ADVAIR is right for you. For more information call 1-800-646-6644, or visit www.ADVAIR.com

Important Information about ADVAIR DISKUS. Prescription ADVAIR won't replace fast-acting inhalers for sudden symptoms and should not be taken more than twice a day. ADVAIR is for people who still have symptoms on another asthma controller, or who need two controllers. ADVAIR contains salmeterol. In patients with asthma, medicines like salmeterol may increase the chance of asthma-related death. So ADVAIR is not for people whose asthma is well controlled on another controller medicine.

Talk to your doctor about the risks and benefits of treating your asthma with ADVAIR. Do not use ADVAIR with long-acting beta₂-agonists for any reason. If you are taking ADVAIR, see your doctor if your asthma does not improve or gets worse. Tell your doctor if you have a heart condition or high blood pressure. Some people may experience increased blood pressure, heart rate, or changes in heart rhythm. ADVAIR is for patients 4 years and older. For patients 4 to 11 years old, ADVAIR 100/50 is for those who have asthma symptoms while on an inhaled corticosteroid.

Please see important information about ADVAIR on the next page.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

 GlaxoSmithKline



If you don't have prescription coverage and can't afford your medicines, visit pparx.org, or call 1-888-4PPA-NOW (1-888-477-2669)

ADVAIR DISKUS[®] 100/50
(fluticasone propionate 100 mcg and salmeterol 50 mcg inhalation powder)

ADVAIR DISKUS[®] 100/50, 250/50, 500/50

(fluticasone propionate 100, 250, 500 mcg and salmeterol 50 mcg inhalation powder)

What is the most important information I should know about ADVAIR DISKUS?

In patients with asthma, long-acting beta₂-agonist medicines such as salmeterol (one of the medications in ADVAIR[®]) may increase the chance of death from asthma problems. In a large asthma study, more patients who used salmeterol died from asthma problems compared with patients who did not use salmeterol. So ADVAIR is not for patients whose asthma is well controlled on another asthma controller medicine such as low- to medium-dose inhaled corticosteroids or only need a fast-acting inhaler once in a while. Talk with your doctor about this risk and the benefits of treating your asthma with ADVAIR.

ADVAIR should not be used to treat a severe attack of asthma or chronic obstructive pulmonary disease (COPD) requiring emergency medical treatment.

ADVAIR should not be used to relieve sudden symptoms or sudden breathing problems. Always have a fast-acting inhaler with you to treat sudden breathing difficulty. If you do not have a fast-acting inhaler, contact your doctor to have one prescribed for you.

What is ADVAIR DISKUS?

There are two medicines in ADVAIR: Fluticasone propionate, an inhaled anti-inflammatory belonging to a group of medicines commonly referred to as corticosteroids; and salmeterol, a long-acting, inhaled bronchodilator belonging to a group of medicines commonly referred to as beta₂-agonists. There are 3 strengths of ADVAIR: 100/50, 250/50, 500/50.

For Asthma

- ADVAIR is approved for the maintenance treatment of asthma in patients 4 years of age and older. ADVAIR should only be used if your doctor decides that another asthma controller medicine alone does not control your asthma or that you need 2 asthma controller medications.
- The strength of ADVAIR approved for patients ages 4 to 11 years who experience symptoms on an inhaled corticosteroid is ADVAIR DISKUS 100/50. All 3 strengths are approved for patients with asthma ages 12 years and older.

For COPD associated with chronic bronchitis

ADVAIR 250/50 is the only approved dose for the maintenance treatment of airflow obstruction in patients with COPD associated with chronic bronchitis. The benefit of using ADVAIR for longer than 6 months has not been evaluated. The way anti-inflammatories work in the treatment of COPD is not well defined.

Who should not take ADVAIR DISKUS?

You should not start ADVAIR if your asthma is becoming significantly or rapidly worse, which can be life threatening. Serious respiratory events, including death, have been reported in patients who started taking salmeterol in this situation, although it is not possible to tell whether salmeterol contributed to these events. This may also occur in patients with less severe asthma.

You should not take ADVAIR if you have had an allergic reaction to it or any of its components (salmeterol, fluticasone propionate, or lactose). Tell your doctor if you are allergic to ADVAIR, any other medications, or food products. If you experience an allergic reaction after taking ADVAIR, stop using ADVAIR immediately and contact your doctor. Allergic reactions are when you experience one or more of the following: choking; breathing problems; swelling of the face, mouth and/or tongue; rash; hives; itching; or welts on the skin.

Tell your doctor about the following:

- If you are using your fast-acting inhaler more often or using more doses than you normally do (e.g., 4 or more inhalations of your fast-acting inhaler for 2 or more days in a row or a whole canister of your fast-acting inhaler in 8 weeks' time), it could be a sign that your asthma is getting worse. If this occurs, tell your doctor immediately.
- If you have been using your fast-acting inhaler regularly (e.g., four times a day). Your doctor may tell you to stop the regular use of these medications.
- If your peak flow meter results decrease. Your doctor will tell you the numbers that are right for you.
- If you have asthma and your symptoms do not improve after using ADVAIR regularly for 1 week.
- If you have been on an oral steroid, like prednisone, and are now using ADVAIR. You should be very careful as you may be less able to heal after surgery, infection, or serious injury. It takes a number of months for the body to recover its ability to make its own steroid hormones after use of oral steroids. Switching from an oral steroid may also unmask a condition previously suppressed by the oral steroid such as allergies, conjunctivitis, eczema, arthritis, and eosinophilic conditions. Symptoms of an eosinophilic condition can include rash, worsening breathing problems, heart complications, and/or feeling of "pins and needles" or numbness in the arms and legs. Talk to your doctor immediately if you experience any of these symptoms.
- Sometimes patients experience unexpected bronchospasm right after taking ADVAIR. This condition can be life threatening and if it occurs, you should immediately stop using ADVAIR and seek immediate medical attention.
- If you have any type of heart disease such as coronary artery disease, irregular heart beat or high blood pressure, ADVAIR should be used with caution. Be sure to talk with your doctor about your condition because salmeterol, one of the components of ADVAIR, may affect the heart by increasing heart rate and blood pressure. It may cause symptoms such as heart fluttering, chest pain, rapid heart rate, tremor, or nervousness.
- If you have seizures, overactive thyroid gland, liver problems, or are sensitive to certain medications for breathing.
- If your breathing problems get worse over time or if your fast-acting inhaler does not work as well for you while using ADVAIR. If your breathing problems worsen quickly, get emergency medical care.
- If you have been exposed to or currently have chickenpox or measles or if you have an immune system problem. Patients using medications that weaken the immune system are more likely to get infections than healthy individuals. ADVAIR contains a corticosteroid (fluticasone propionate) which may weaken the immune system. Infections like chickenpox and measles, for example, can be very serious or even fatal in susceptible patients using corticosteroids.

How should I take ADVAIR DISKUS?

ADVAIR should be used 1 inhalation, twice a day (morning and evening). ADVAIR should never be taken more than 1 inhalation twice a day. The full benefit of taking ADVAIR may take 1 week or longer.

If you miss a dose of ADVAIR, just skip that dose. Take your next dose at your usual time. Do not take two doses at one time.

Do not stop using ADVAIR unless told to do so by your doctor because your symptoms might get worse.

Do not change or stop any of your medicines used to control or treat your breathing problems. Your doctor will adjust your medicines as needed.

When using ADVAIR, remember:

- Never breathe into or take the DISKUS[®] apart.
- Always use the DISKUS in a level position.
- **After** each inhalation, rinse your mouth with water without swallowing.
- Never wash any part of the DISKUS. Always keep it in a dry place.
- Never take an extra dose, even if you feel you did not receive a dose.
- Discard 1 month after removal from the foil pouch.
- Do not use ADVAIR with a spacer device.

Children should use ADVAIR with an adult's help as instructed by the child's doctor.

Can I take ADVAIR DISKUS with other medications?

Tell your doctor about all the medications you take, including prescription and nonprescription medications, vitamins, and herbal supplements.

If you are taking ADVAIR DISKUS, do not use other long-acting beta₂-agonist-containing medications, such as SEREVENT[®] DISKUS or Foradil[®] Aerolizer[®], or any reason.

If you take ritonavir (an HIV medication), tell your doctor. Ritonavir may interact with ADVAIR and could cause serious side effects. The anti-HIV medicines Norvir[®] Soft Gelatin Capsules, Norvir Oral Solution, and Kaletra[®] contain ritonavir.

No formal drug interaction studies have been performed with ADVAIR.

In clinical studies, there were no differences in effects on the heart when ADVAIR was taken with varying amounts of albuterol. The effect of using ADVAIR in patients with asthma while taking more than 9 puffs a day of albuterol has not been studied.

ADVAIR should be used with extreme caution during and up to 2 weeks after treatment with monoamine oxidase (MAO) inhibitors or tricyclic antidepressants since these medications can cause ADVAIR to have an even greater effect on the circulatory system.

ADVAIR should be used with caution in people who are taking ketoconazole (an antifungus medication) or other drugs broken down by the body in a similar way. These medications can cause ADVAIR to have greater steroid side effects.

Generally, people with asthma should not take beta-blockers because they counteract the effects of beta₂-agonists and may also cause severe bronchospasm. However, in some cases, for instance, following a heart attack, selective beta-blockers may still be used if there is no acceptable alternative.

The ECG changes and/or low blood potassium that may occur with some diuretics may be made worse by ADVAIR, especially at higher-than-recommended doses. Caution should be used when these drugs are used together.

In clinical studies, there was no difference in side effects when ADVAIR was taken with methylxanthines (e.g., theophylline) or with FLONASE[®] (fluticasone propionate).

What are other important safety considerations with ADVAIR DISKUS?

Pneumonia: Lower respiratory tract infections, including pneumonia, have been reported with the use of inhaled corticosteroids, including ADVAIR. There was a higher incidence of pneumonia reported in patients with COPD taking ADVAIR DISKUS in clinical studies.

Osteoporosis: Long-term use of inhaled corticosteroids may result in bone loss (osteoporosis). Patients who are at risk for increased bone loss (tobacco use, advanced age, inactive lifestyle, poor nutrition, family history of osteoporosis, or long-term use of drugs such as corticosteroids) may have a greater risk with ADVAIR. If you have risk factors for bone loss, you should talk to your doctor about ways to reduce your risk and whether you should have your bone density evaluated.

Glaucoma and cataracts: Glaucoma, increased pressure in the eyes, and cataracts have been reported with the use of inhaled steroids, including fluticasone propionate, a medicine contained in ADVAIR. Regular eye examinations should be considered if you are taking ADVAIR.

Blood sugar: Salmeterol may affect blood sugar and/or cause low blood potassium in some patients, which could lead to a side effect like an irregular heart rate. Significant changes in blood sugar and blood potassium were seen infrequently in clinical studies with ADVAIR.

Growth: Inhaled steroids may cause a reduction in growth velocity in children and adolescents.

Steroids: Taking steroids can affect your body's ability to make its own steroid hormones, which are needed during infections and times of severe stress to your body, such as an operation. These effects can sometimes be seen with inhaled steroids (but it is more common with oral steroids), especially when taken at higher-than-recommended doses over a long period of time. In some cases, these effects may be severe. Inhaled steroids often help control symptoms with less side effects than oral steroids.

Yeast infections: Patients taking ADVAIR may develop yeast infections of the mouth and/or throat ("thrush") that should be treated by their doctor.

Tuberculosis or other untreated infections: ADVAIR should be used with caution, if at all, in patients with tuberculosis, herpes infections of the eye, or other untreated infections.

What are the other possible side effects of ADVAIR DISKUS?

ADVAIR may produce side effects in some patients. In clinical studies, the most common side effects with ADVAIR included:

- | | | |
|--------------------------------|-----------------------|------------------------------------|
| • Respiratory infections | • Bronchitis | • Musculoskeletal pain |
| • Throat irritation | • Cough | • Dizziness |
| • Hoarseness | • Headaches | • Fever |
| • Sinus infection | • Nausea and vomiting | • Ear, nose, and throat infections |
| • Yeast infection of the mouth | • Diarrhea | • Nosebleed |

Tell your doctor about any side effect that bothers you or that does not go away. These are not all the side effects with ADVAIR. Ask your doctor or pharmacist for more information.

What if I am pregnant, planning to become pregnant, or nursing?

Talk to your doctor about the benefits and risks of using ADVAIR during pregnancy, labor, or if you are nursing. There have been no studies of ADVAIR used during pregnancy, labor, or in nursing women. Salmeterol is known to interfere with labor contractions. It is not known whether ADVAIR is excreted in breast milk, but other corticosteroids have been detected in human breast milk. Fluticasone propionate, like other corticosteroids, has been associated with birth defects in animals (e.g., cleft palate and fetal death). Salmeterol showed no effect on fertility in rats at 180 times the maximum recommended daily dose.

What other important tests were conducted with ADVAIR?

There is no evidence of enhanced toxicity with ADVAIR compared with the components administered separately. In animal studies with doses much higher than those used in humans, salmeterol was associated with uterine tumors. Your healthcare professional can tell you more about how drugs are tested on animals and what the results of these tests may mean to your safety.

For more information on ADVAIR DISKUS

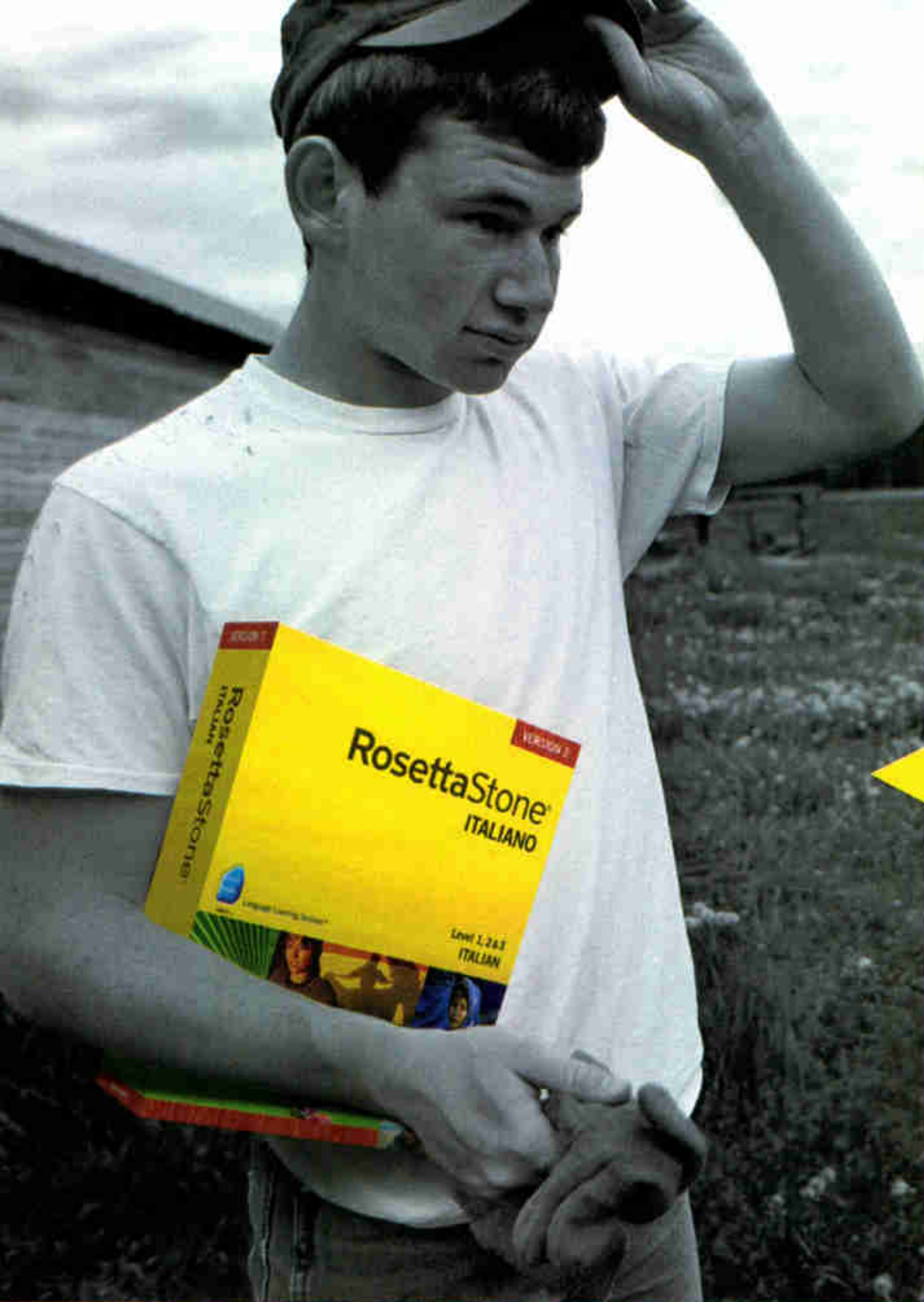
This page is only a brief summary of important information about ADVAIR DISKUS. For more information, talk to your doctor. You can also visit www.ADVAIR.com or call 1-888-825-5249. Patients receiving ADVAIR DISKUS should read the medication guide provided by the pharmacist with the prescription.

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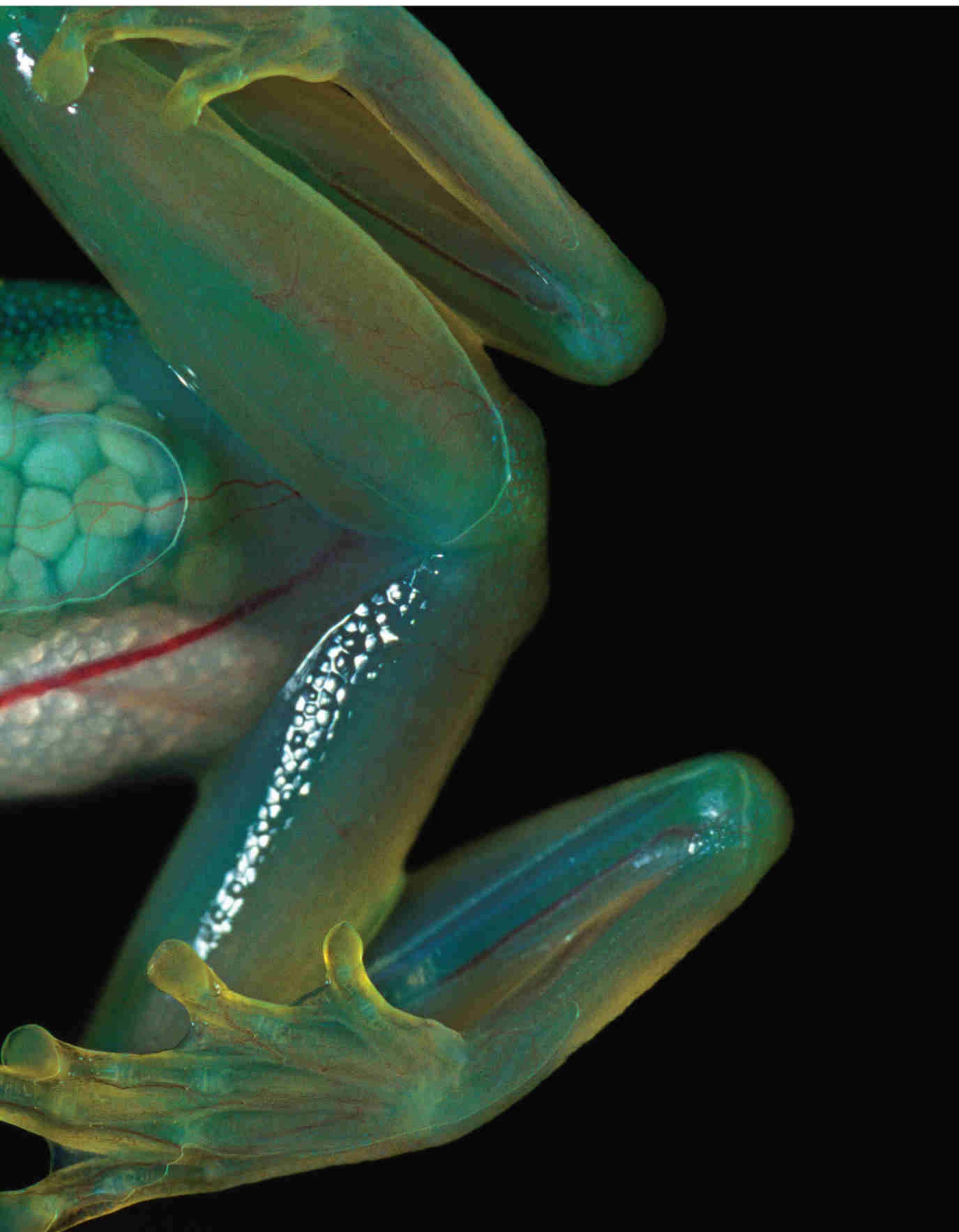
Antarctica Not far from its Franklin Island colony, a lone Adélie punctuates the looping scrawl of penguin tracks across plates of Ross Sea pack ice. Some 2.7 million of the birds populate the Ross Sea region.

PHOTO: JOHN B. WELLER



Germany The see-through skin of an inch-long glass frog reveals her eggs. Native to Venezuela, the frogs lay eggs in bushes and trees overhanging streams. Tadpoles hatch, then tumble into the current to be swept away.





United States A red-clay spray showers spectators at the mud-pit belly flop, highlight of the annual Summer Redneck Games in East Dublin, Georgia. Other events include a hubcap-discus throw and bobbing for pigs' feet.



➤ See more Visions of Earth images at [visionsofearth.ngm.com](https://www.visionsofearth.ngm.com).

PHOTO: SOL NEELMAN



F O S S I L S

Kin by a Nose Mastodons and mammoths, extinct cousins of the elephant, were members of the order Proboscidea—animals with trunks. Recent discoveries (in Russia, Greece, and the U.S.) have put both beasts back in the spotlight. But how did they differ?

MASTODONS (*below, left*): About the size of today's elephants, though more stoutly built, these ancient browsers had straight backs and a taste for twigs and leaves.

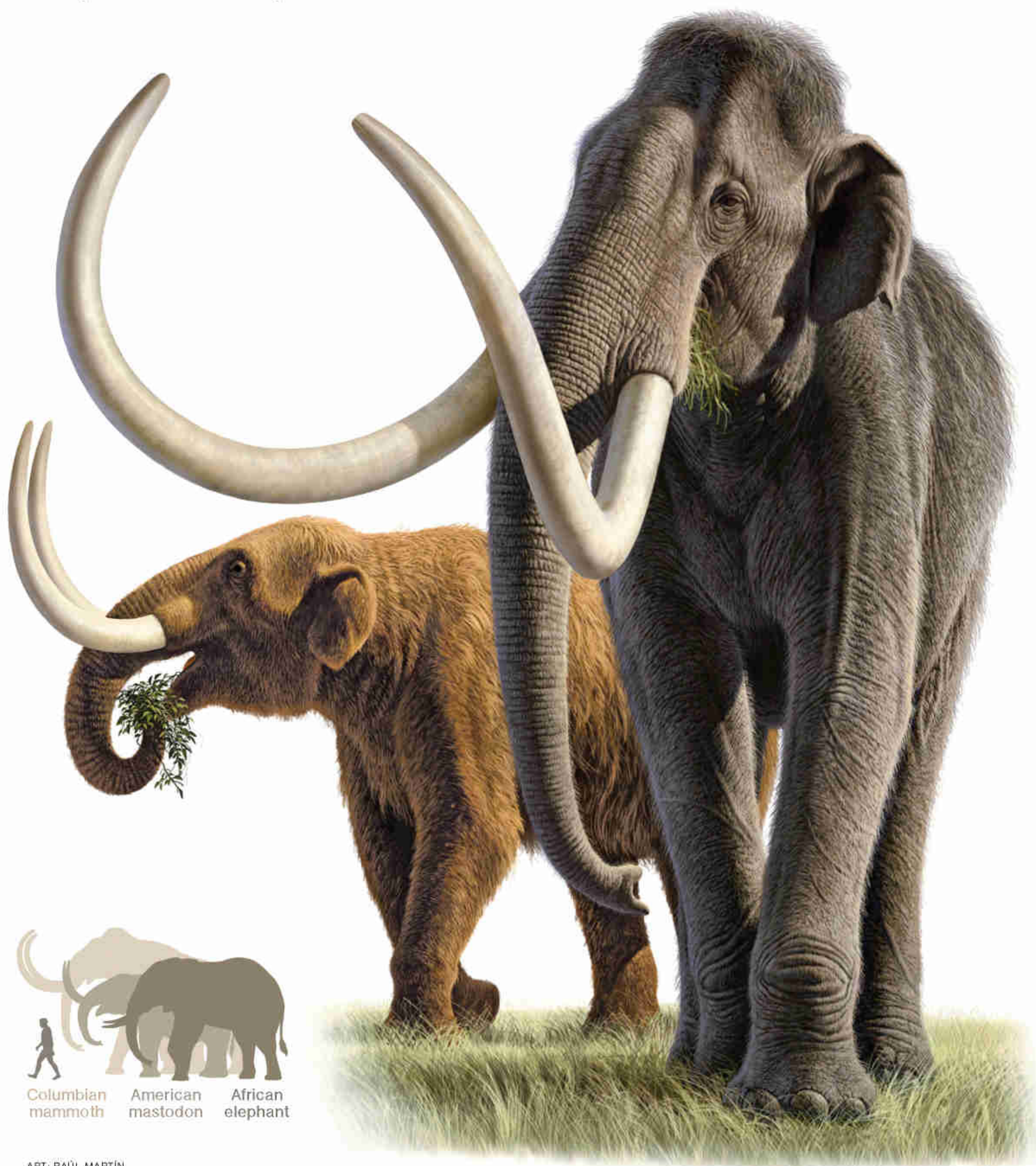
MAMMOTHS (*right*): As tall as 13 feet at the shoulder, with short tails, sloping backs, and spiraling tusks, these behemoths were grazers that fancied grasses. —A. R. Williams

Teeth: Cone-shaped cusps (left) were used to crush. Flat, ridged ones (right) were good for grinding.



Mastodon

Mammoth



Columbian mammoth American mastodon African elephant



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Non-narcotic LUNESTA has helped
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(eszopiclone)[®]
1, 2 AND 3 MG TABLETS

A great tomorrow starts tonight.

IMPORTANT SAFETY INFORMATION:

LUNESTA helps you fall asleep quickly, so take it right before bed. Be sure you have at least eight hours to devote to sleep before becoming active. Until you know how you'll react to LUNESTA, you should not drive or operate machinery. Do not take LUNESTA with alcohol. Call your doctor right away if after taking LUNESTA you walk, drive, eat or engage in other activities while asleep. In rare cases severe allergic reactions can occur. Most sleep medicines carry some risk of dependency. Side effects may include unpleasant taste, headache, drowsiness and dizziness. You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088. See important patient information on the next page.



Please read this summary of information about LUNESTA before you talk to your doctor or start using LUNESTA. It is not meant to take the place of your doctor's instructions. If you have any questions about LUNESTA tablets, be sure to ask your doctor or pharmacist.

LUNESTA is used to treat different types of sleep problems, such as difficulty in falling asleep, difficulty in maintaining sleep during the night, and waking up too early in the morning. Most people with insomnia have more than one of these problems. You should take LUNESTA immediately before going to bed because of the risk of falling.

LUNESTA belongs to a group of medicines known as "hypnotics" or, simply, sleep medicines. There are many different sleep medicines available to help people sleep better. Insomnia is often transient and intermittent. It usually requires treatment for only a short time, usually 7 to 10 days up to 2 weeks. If your insomnia does not improve after 7 to 10 days of treatment, see your doctor, because it may be a sign of an underlying condition. Some people have chronic sleep problems that may require more prolonged use of sleep medicine. However, you should not use these medicines for long periods without talking with your doctor about the risks and benefits of prolonged use.

Side Effects

All medicines have side effects. The most common side effects of sleep medicines are:

- Drowsiness
- Dizziness
- Lightheadedness
- Difficulty with coordination

Sleep medicines can make you sleepy during the day. How drowsy you feel depends upon how your body reacts to the medicine, which sleep medicine you are taking, and how large a dose your doctor has prescribed. Daytime drowsiness is best avoided by taking the lowest dose possible that will still help you sleep at night. Your doctor will work with you to find the dose of LUNESTA that is best for you. Some people taking LUNESTA have reported next-day sleepiness.

To manage these side effects while you are taking this medicine:

- When you first start taking LUNESTA or any other sleep medicine, until you know whether the medicine will still have some effect on you the next day, use extreme care while doing anything that requires complete alertness, such as driving a car, operating machinery, or piloting an aircraft.
- Do not drink alcohol when you are taking LUNESTA or any sleep medicine. Alcohol can increase the side effects of LUNESTA or any other sleep medicine.
- Do not take any other medicines without asking your doctor first. This includes medicines you can buy without a prescription. Some medicines can cause drowsiness and are best avoided while taking LUNESTA.
- Always take the exact dose of LUNESTA prescribed by your doctor. Never change your dose without talking to your doctor first.

Special Concerns

There are some special problems that may occur while taking sleep medicines.

Memory Problems

Sleep medicines may cause a special type of memory loss or "amnesia." When this occurs, a person may not remember what has happened for several hours after taking the medicine. This is usually not a problem since most people fall asleep after taking the medicine. Memory loss can be a problem, however, when sleep medicines are taken while traveling, such as during an airplane flight and the person wakes up before the effect of the medicine is gone. This has been called "traveler's amnesia." Memory problems have been reported rarely by patients taking LUNESTA in clinical studies. In most cases, memory problems can be avoided if you take LUNESTA only when you are able to

get a full night of sleep before you need to be active again. Be sure to talk to your doctor if you think you are having memory problems.

Tolerance

When sleep medicines are used every night for more than a few weeks, they may lose their effectiveness in helping you sleep. This is known as "tolerance." Development of tolerance to LUNESTA was not observed in a clinical study of 6 months' duration. Insomnia is often transient and intermittent, and prolonged use of sleep medicines is generally not necessary. Some people, though, have chronic sleep problems that may require more prolonged use of sleep medicine. If your sleep problems continue, consult your doctor, who will determine whether other measures are needed to overcome your sleep problems.

Dependence

Sleep medicines can cause dependence in some people, especially when these medicines are used regularly for longer than a few weeks or at high doses. Dependence is the need to continue taking a medicine because stopping it is unpleasant. When people develop dependence, stopping the medicine suddenly may cause unpleasant symptoms (see *Withdrawal* below). They may find they have to keep taking the medicine either at the prescribed dose or at increasing doses just to avoid withdrawal symptoms.

All people taking sleep medicines have some risk of becoming dependent on the medicine. However, people who have been dependent on alcohol or other drugs in the past may have a higher chance of becoming addicted to sleep medicines. This possibility must be considered before using these medicines for more than a few weeks. If you have been addicted to alcohol or drugs in the past, it is important to tell your doctor before starting LUNESTA or any sleep medicine.

Withdrawal

Withdrawal symptoms may occur when sleep medicines are stopped suddenly after being used daily for a long time. In some cases, these symptoms can occur even if the medicine has been used for only a week or two. In mild cases, withdrawal symptoms may include unpleasant feelings. In more severe cases, abdominal and muscle cramps, vomiting, sweating, shakiness, and, rarely, seizures may occur. These more severe withdrawal symptoms are very uncommon. Although withdrawal symptoms have not been observed in the relatively limited controlled trials experience with LUNESTA, there is, nevertheless, the risk of such events in association with the use of any sleep medicine.

Another problem that may occur when sleep medicines are stopped is known as "rebound insomnia." This means that a person may have more trouble sleeping the first few nights after the medicine is stopped than before starting the medicine. If you should experience rebound insomnia, do not get discouraged. This problem usually goes away on its own after 1 or 2 nights.

If you have been taking LUNESTA or any other sleep medicine for more than 1 or 2 weeks, do not stop taking it on your own. Always follow your doctor's directions.

Changes In Behavior And Thinking

Some people using sleep medicines have experienced unusual changes in their thinking and/or behavior. These effects are not common. However, they have included:

- More outgoing or aggressive behavior than normal
- Confusion
- Strange behavior
- Agitation
- Hallucinations
- Worsening of depression
- Suicidal thoughts

How often these effects occur depends on several factors, such as a person's general health, the use of other medicines, and which sleep medicine is being used. Clinical experience with LUNESTA suggests that it is rarely associated with these behavior changes.

It is also important to realize it is rarely clear whether these behavior changes are caused by the medicine, are caused by an illness, or have occurred on their own. In fact, sleep problems that do not

improve may be due to illnesses that were present before the medicine was used. If you or your family notice any changes in your behavior, or if you have any unusual or disturbing thoughts, call your doctor immediately.

Pregnancy And Breastfeeding

Sleep medicines may cause sedation or other potential effects in the unborn baby when used during the last weeks of pregnancy. Be sure to tell your doctor if you are pregnant, if you are planning to become pregnant, or if you become pregnant while taking LUNESTA.

In addition, a very small amount of LUNESTA may be present in breast milk after use of the medication. The effects of very small amounts of LUNESTA on an infant are not known; therefore, as with all other prescription sleep medicines, it is recommended that you not take LUNESTA if you are breastfeeding a baby.

Safe Use Of Sleep Medicines

To ensure the safe and effective use of LUNESTA or any other sleep medicine, you should observe the following cautions:

1. LUNESTA is a prescription medicine and should be used ONLY as directed by your doctor. Follow your doctor's instructions about how to take, when to take, and how long to take LUNESTA.
2. Never use LUNESTA or any other sleep medicine for longer than directed by your doctor.
3. If you notice any unusual and/or disturbing thoughts or behavior during treatment with LUNESTA or any other sleep medicine contact your doctor.
4. Tell your doctor about any medicines you may be taking, including medicines you may buy without a prescription and herbal preparations. You should also tell your doctor if you drink alcohol. DO NOT use alcohol while taking LUNESTA or any other sleep medicine.
5. Do not take LUNESTA unless you are able to get 8 or more hours of sleep before you must be active again.
6. Do not increase the prescribed dose of LUNESTA or any other sleep medicine unless instructed by your doctor.
7. When you first start taking LUNESTA or any other sleep medicine, until you know whether the medicine will still have some effect on you the next day, use extreme care while doing anything that requires complete alertness, such as driving a car, operating machinery, or piloting an aircraft.
8. Be aware that you may have more sleeping problems the first night or two after stopping any sleep medicine.
9. Be sure to tell your doctor if you are pregnant, if you are planning to become pregnant, if you become pregnant, or if you are breastfeeding a baby while taking LUNESTA.
10. As with all prescription medicines, never share LUNESTA or any other sleep medicine with anyone else. Always store LUNESTA or any other sleep medicine in the original container and out of reach of children.
11. Be sure to tell your doctor if you suffer from depression.
12. LUNESTA works very quickly. You should only take LUNESTA immediately before going to bed.
13. For LUNESTA to work best, you should not take it with or immediately after a high-fat, heavy meal.
14. Some people, such as older adults (i.e., ages 65 and over) and people with liver disease, should start with the lower dose (1 mg) of LUNESTA. Your doctor may choose to start therapy at 2 mg. In general, adults under age 65 should be treated with 2 or 3 mg.
15. Each tablet is a single dose; do not crush or break the tablet.

Note: This summary provides important information about LUNESTA. If you would like more information, ask your doctor or pharmacist to let you read the Prescribing Information and then discuss it with him or her.

Rx only



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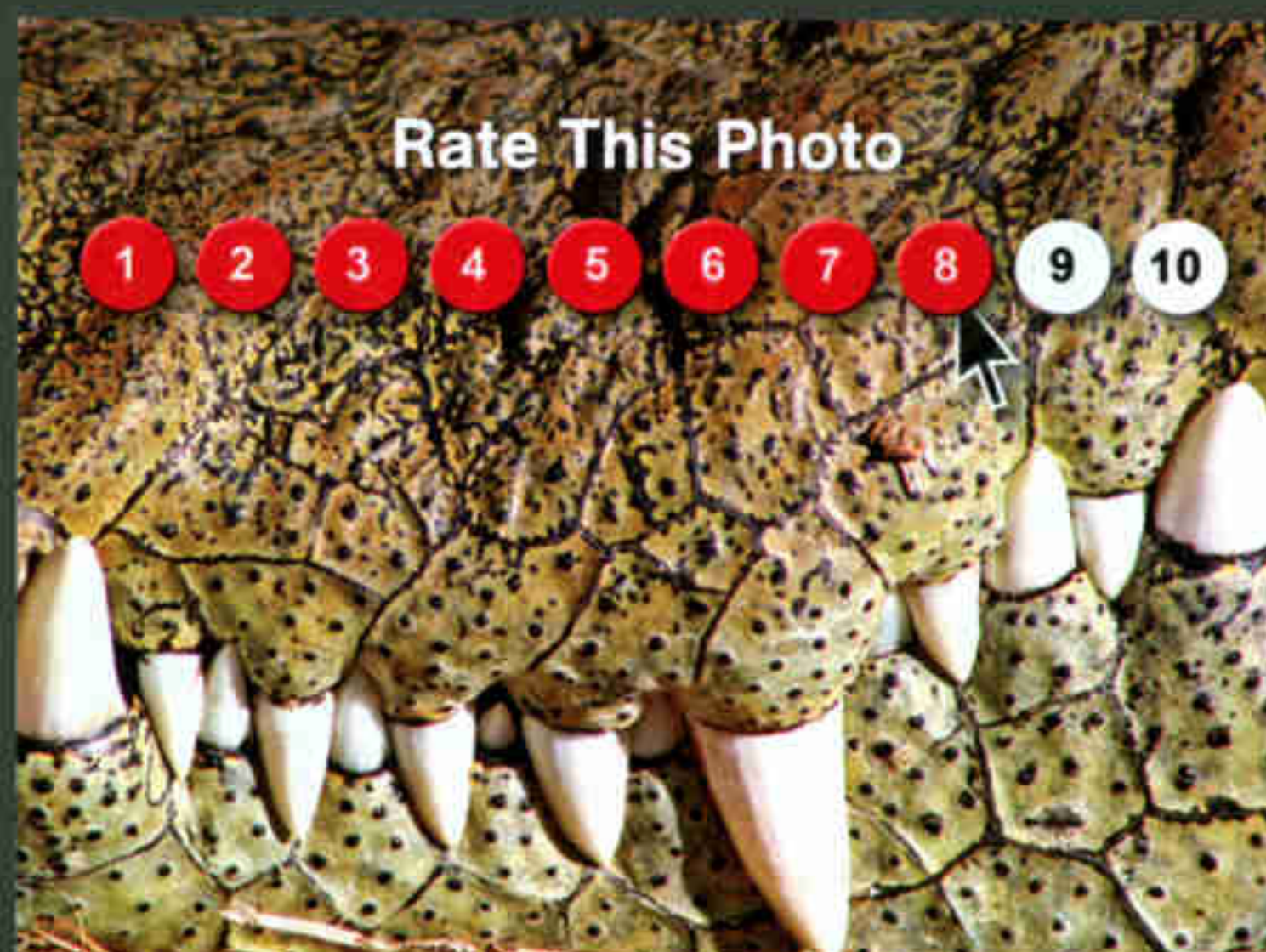
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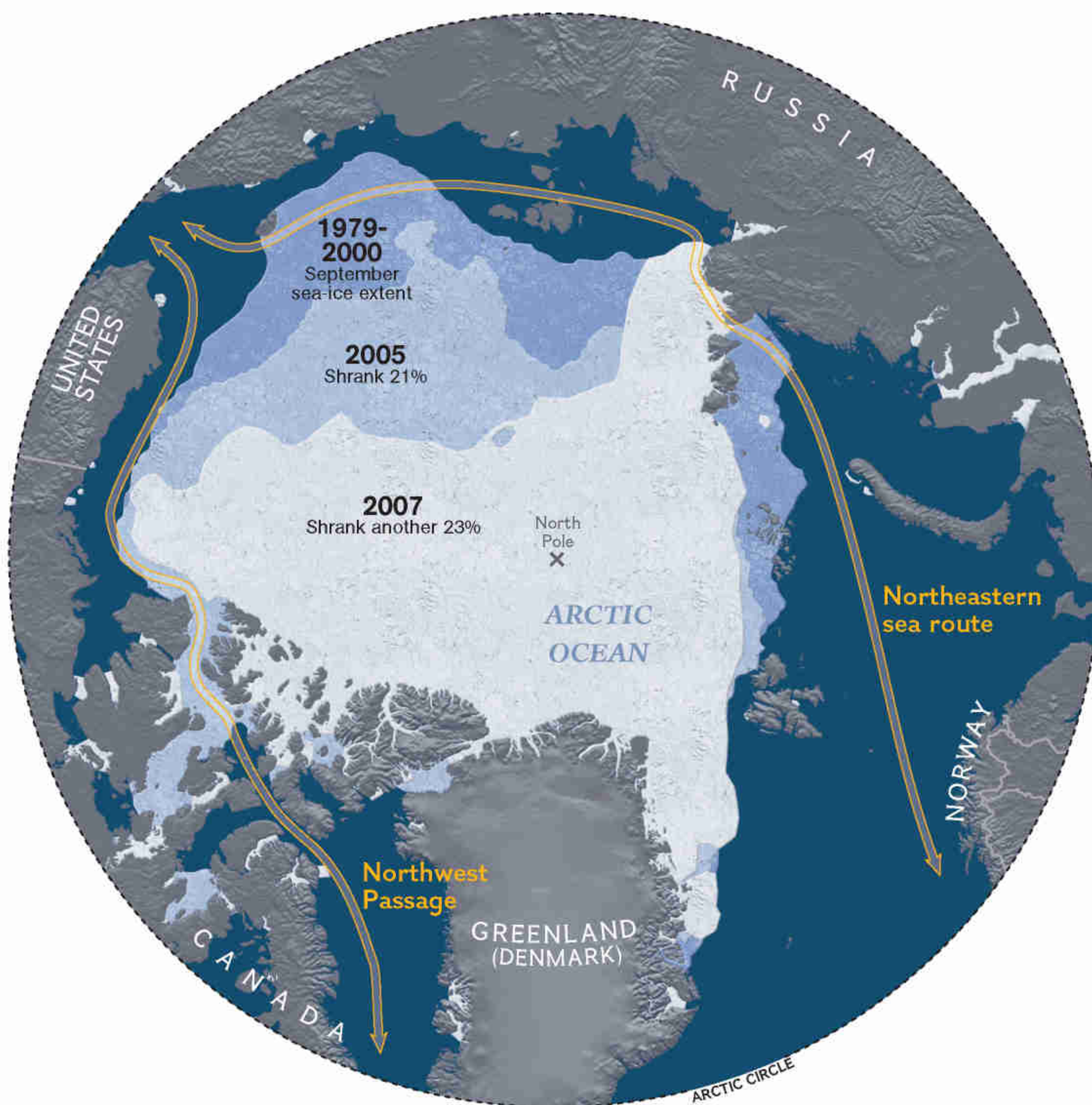


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A once frozen passage opens.

Polar Bare Arctic sea ice always shrinks as summer warms the top of the world. But last year's melt was a stunner: By September the ice cover had declined from its previous low, in 2005, by an area larger than Texas and California combined, opening sea routes usually limited to icebreakers. In 1979, September ice extended 2.78 million square miles; last year it was 1.65 million. Scientists predicted global warming would mean the end of a year-round polar ice cap but didn't expect that until the late 21st century. Research published in 2007, however, says the meltdown is ahead of schedule and that the polar region could be open water by summer 2030. Or sooner. One oceanographer, using a different model, says 2013 could be the end of the Arctic as we know it. —Chris Carroll

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Bird Blitz At one second after midnight on the second Saturday in May hundreds of birders around New Jersey will begin a competition that ends 24 frantic, caffeine-fueled hours later, when the World Series of Birding names its champions.

Teams vie in various categories, including grade-schoolers and over-55s. Winners identify the highest number of species within the state, from the conifer forests of Kittatinny Mountain

to the salt marshes by the Delaware Bay. The top team total was 231 in 2003. Participants solicit pledges based on

species count and have raised more than eight million dollars for environmental causes over the 24 years of the New Jersey Audubon Society event.

Bad weather? Flat tires? Jersey traffic? It's all part of the game. —Mel White

▶ **Play On!** Read an account of the event at ngm.com.

The World Series Playing Field

Teams may begin and end their route anywhere within the state. All vehicles may be used—except aircraft.



Here are six prize finds at the World Series of Birding.

Least Bittern

Ixobrychus exilis
13 inches (length)
The ku-ku-ku call in the marshes of New Jersey's Great Swamp National Wildlife Refuge is from this secretive species.

Northern Saw-whet Owl

Aegolius acadicus
8 inches
It takes luck (or precontest scouting) to find this tiny owl, named for its raspy call of alarm—like a saw being sharpened.

Surf Scoter

Melanitta perspicillata
20 inches
Teams scan the Atlantic Ocean for the three species of sea ducks called scoters: surf, black, and white-winged.

Common Raven

Corvus corax
24 inches
A familiar bird in western mountains, the common raven only rarely nests in New Jersey. Its croaking call is deeper than the American crow's familiar caw.

Summer Tanager

Piranga rubra
7.75 inches
Birders listen for the summer tanager's robin-like song in southern New Jersey's pine-oak woods. Its relative, the scarlet tanager, is more widespread in the state.

Yellow-crowned Night Heron

Nyctanassa violacea
24 inches
Southeastern wetlands are home to a small number of this mostly nocturnal heron, which feeds on crabs, crayfish, and frogs.



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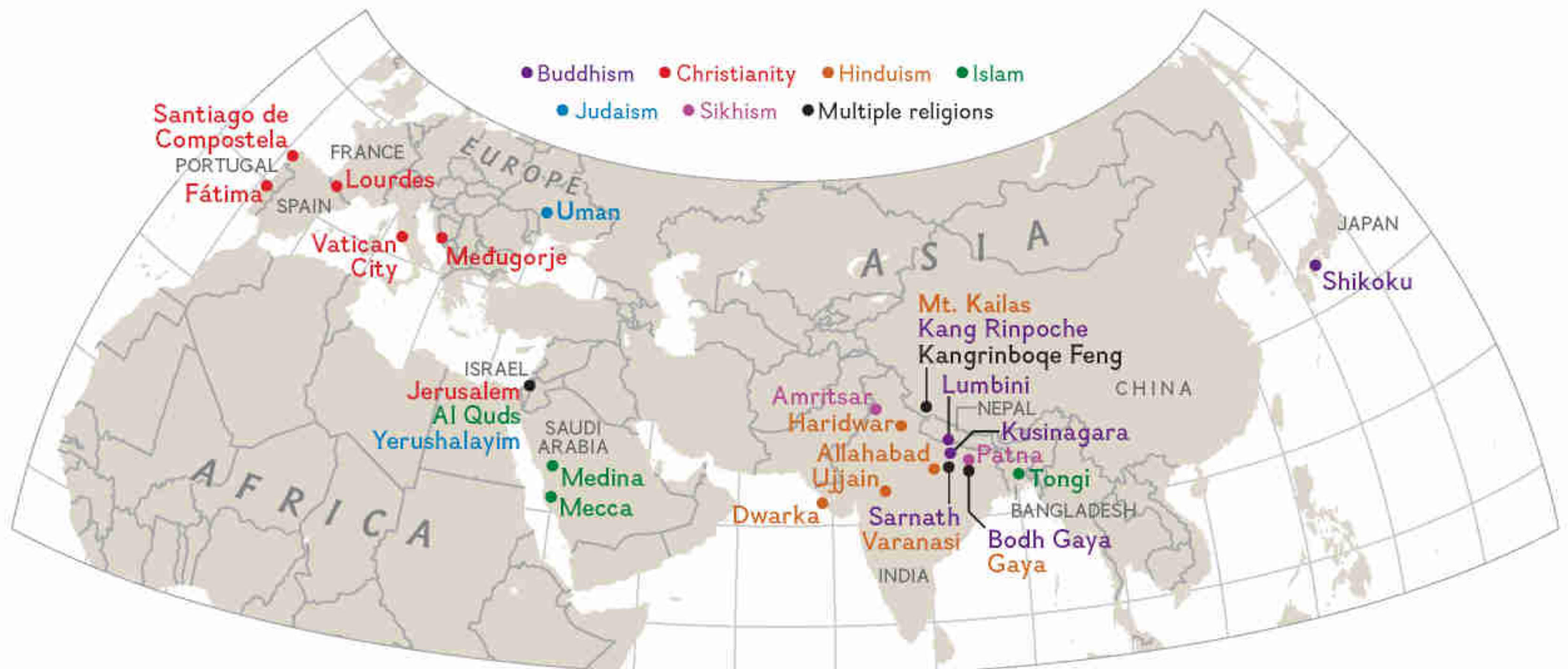
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Pilgrims' Progress

More and more, the faithful are flocking to pilgrimage sites on and off the beaten path. Detailed below: four places with a rising profile.



Medjugorje, Bosnia and Herzegovina
In 1981 village youth said they saw the Virgin Mary on a cloud. Pilgrim count since then: millions.

Uman, Ukraine
The grave of Rabbi Nachman of Bratslav inspired the pilgrimage movie *Yippee: A Journey to Jewish Joy*.

Mt. Kailas, China
Buddhists, Hindus, and others circle the peak to shed sins. Visits are increasing as travel to the area grows easier.

Tongi, Bangladesh
Last year a record 3 million Muslims, from 80 lands, sought blessings at the 3-day Bishwa Ijtema gathering.



Tens of millions of Hindu devotees come to Allahabad, India, each year for a "holy dip" in the Ganges River.

Faith tourism is a fast-growing industry that serves some 300 million travelers and produces an estimated 18 billion dollars in revenue a year. In India and Saudi Arabia, hotel chains are building for an influx; North American tour companies now cater to what was once perceived as a niche market. Rising disposable income, lower travel costs, and a desire to find journeys with a purpose are fueling what Kevin J. Wright, president of the World Religious Travel Association, describes as an increase in interest across faiths, both in traditional sites and in lesser known spots. Sometimes the shrine is new—Pope John Paul II's Vatican tomb. Others are in regions that until recently had been politically off-limits—Tibet, for instance. Whatever the destination, contemporary pilgrims seek what pilgrims always have, says religious-travel scholar David Gitlitz, "contact points between the human and the divine" at sites where they feel their prayers may be imbued with greater meaning and resonance. —Diane Cole

A photograph of a dark-colored sedan with its hood open, parked in a vast, flat, grassy field under a cloudy sky. Several utility poles with power lines are visible in the background, stretching into the distance. The scene conveys a sense of being isolated in a remote area.

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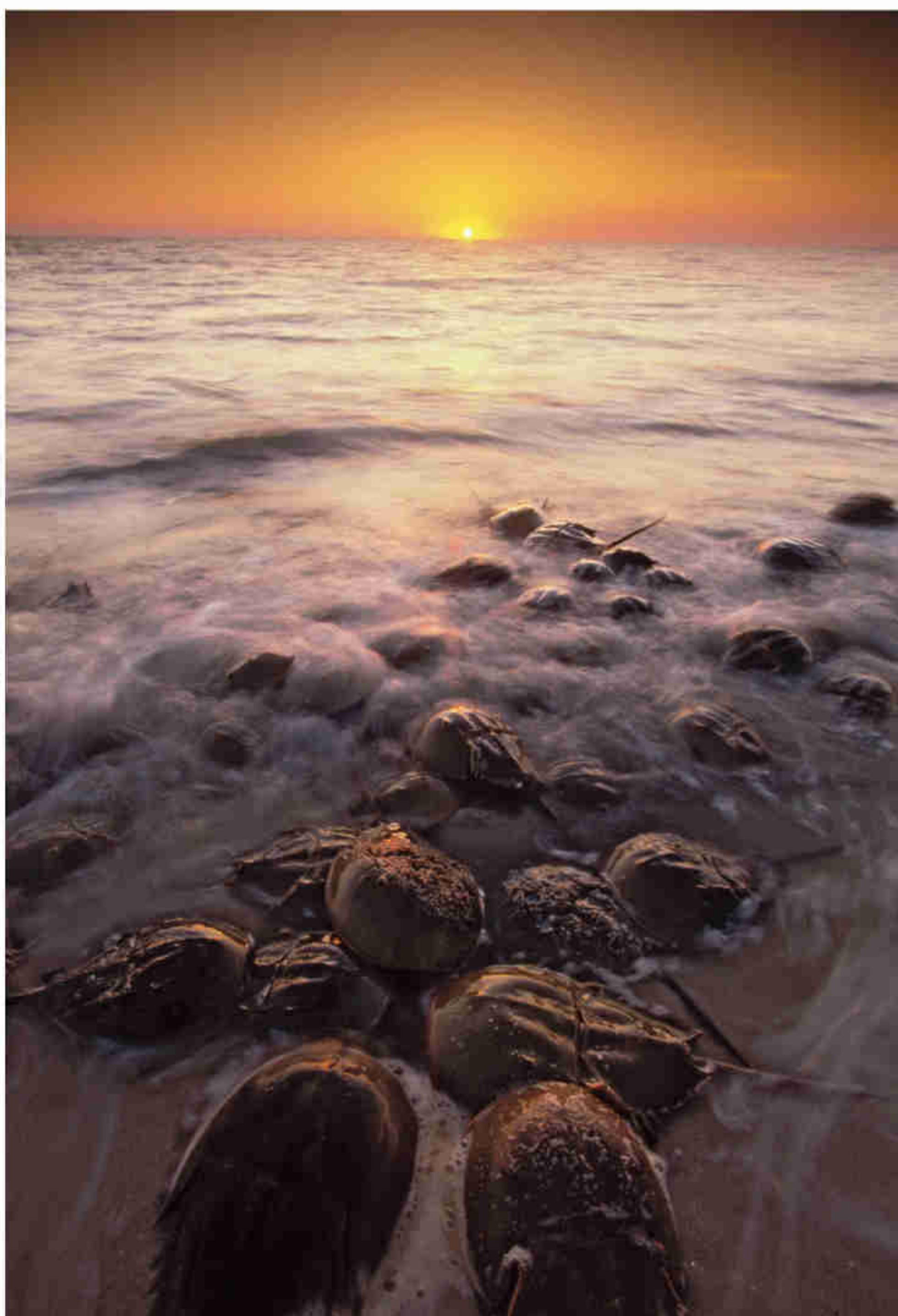
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CONSERVATION



Egg Stop Each year, the red knots of Tierra del Fuego take a mighty flight. In February the shorebirds embark on a 9,300-mile trip to the Arctic—one of the world's longest migration routes. And they wouldn't make it without a Delaware Bay layover.



In spring the hungry birds arrive. On the menu: horseshoe crab eggs. The crabs lay eggs in the sand, and red knots dig in. At the bay each bird must nearly double in weight, to about 6.4 ounces. Skinny birds can succumb to bad weather in their northern nesting grounds, if they make it at all. But horseshoe crabs are now harder to find. Since the early 1990s growing conch and eel fisheries have been using them as bait. Fewer crabs mean fewer eggs; fewer eggs mean fewer red knots. In Tierra del Fuego their numbers have fallen from 68,000 in 1985 to 17,000 in 2007. If the horseshoe harvests continue, red knots could be flying on empty. —Helen Fields



Horseshoe crabs mate (top) and lay eggs (right) that feed red knots every May at the Delaware Bay, a crucial stop on their long northbound migration.



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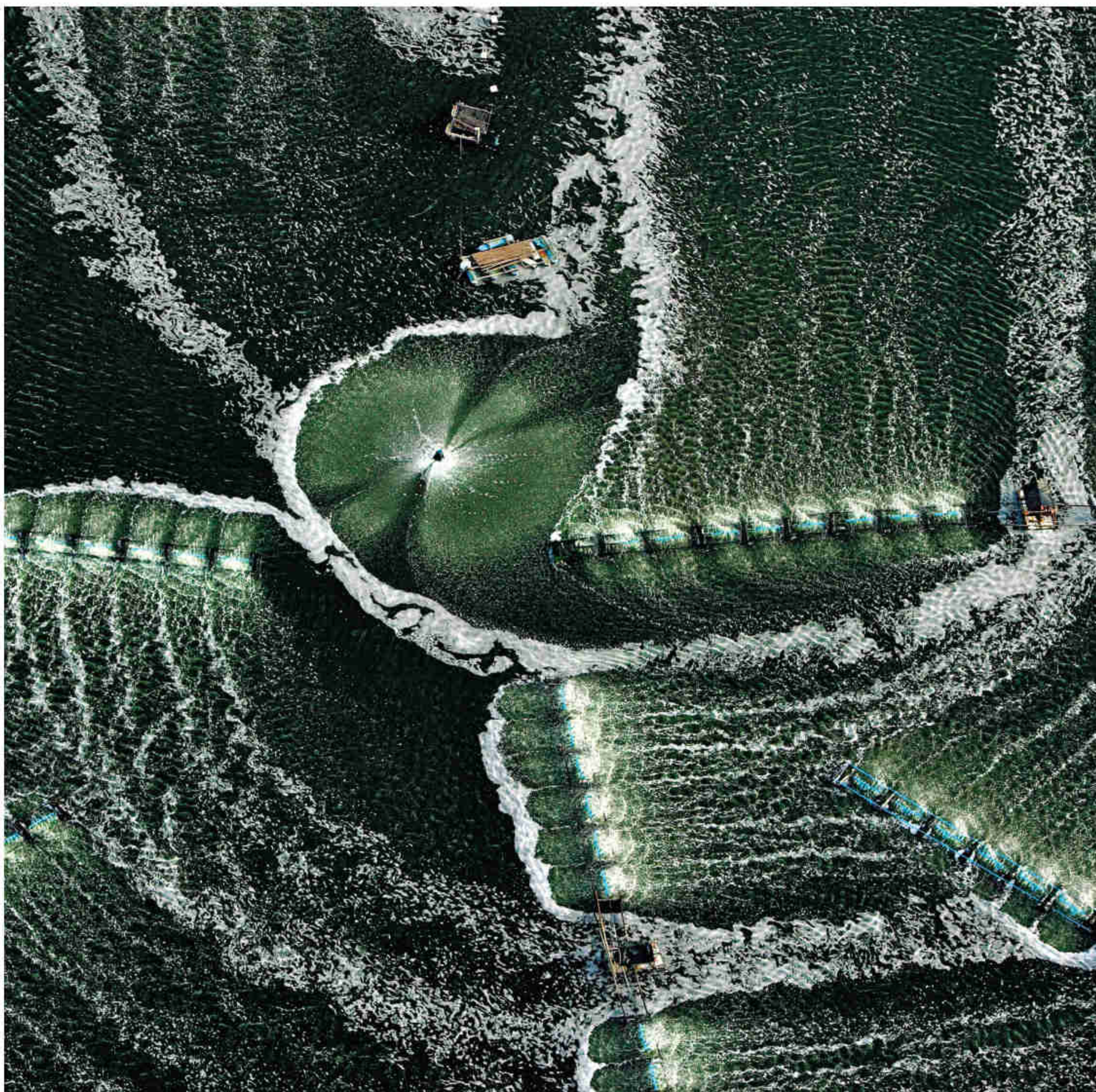
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WHERE IN THE WORLD?



Growing shrimp is big business in Thailand but puts a big strain on coastal environments.

Shrimp Dip Water moves like clockwork through a shrimp farm in Thailand's Phang Nga Bay on the Andaman Sea. Splash and foam from paddle-wheel aerators, which circulate and oxygenate, leave white trails across the otherwise phytoplankton-green pool. A vertical aerator (center) sprays in the round. Commercial shrimp farming is jumbo business in Thailand: Over 30,000 farms countrywide produced about 280,000 tons of shrimp in 2006, and exports to Europe, Japan, and the U.S. earned more than two billion dollars. The environmental impact is also sizable. Scores of mangrove forests, which protect coastlines from storms and erosion and cradle valuable fish, have been felled for aquaculture. No other Thai industry has done as much damage to these vital ecosystems. What's more, because of overfeeding and chemical dousings to squeeze out high yields, the farms cannot be sustained long term. —Jennifer S. Holland



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The Evolution of Gum

The next time you curse that wad of chewing gum stuck to your shoe, consider that you are adhered to a piece of history. In July 2007 a 5,500-year-old lump of birch-bark tar imprinted with teeth marks (above left) was discovered in Finland, but our need to chew dates back even further. "The history of chewing gum is surely longer than 10,000 years," says Sami Viljanmaa, a supervisor at the Finnish dig. "How much longer is what we have to find out." —Winona Dimeo-Ediger

ORAL FIXATION

4000-3500 B.C. Birch-bark tar is used as an adhesive to repair pottery and arrowheads. Archaeologists believe Neolithic people also made use of its antiseptic properties, chewing the "gum" to treat mouth infections.

A.D. 50 Ancient Greeks chew the resin from the mastic tree.

1500s Spanish records describe Maya chewing chicle made from the sap of the sapodilla tree.

STARTING TO STICK

1600s Native Americans share their chewing habit with European colonists.

1848 John Curtis introduces State of Maine Pure Spruce Gum, the first gum to be sold commercially.

1860s Mexican general Antonio López de Santa Anna comes to the United States. He brings chicle to New York, hoping to sell it to make rubber.

1869 William Semple, an Ohio dentist, receives the first patent for chewing gum.

IN THE PINK

1891 William Wrigley, Jr., gives away two packs of chewing gum with each can of baking powder he sells. The gum quickly becomes more popular. Doublemint twins and Wrigley Field follow.

1928 Walter Diemar accidentally creates a recipe for bubble gum. He adds the only food coloring he has on hand: bright pink.

1941-45 Dubble Bubble gum is distributed to soldiers with their rations. American forces blow bubbles from Paris to the Philippines, boosting its popularity.

CHEWS IN THE NEWS

1950s Sugarless gum hits the market.

1996 Nicorette, the first nicotine gum used as an aid to quit smoking, is made available over the counter.

2004 Singapore relaxes its infamous ban on chewing gum.

2007 Scientists develop and test a gum that may degrade in water and is easily removed from pavement or clothing.



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A Deadly Diet for Vultures In India, vultures were once too common to bother counting—there were probably tens of millions. But in the early 1990s three species began dying. Searching for a culprit, scientists ruled out viruses and bacteria, and landed on diclofenac, an anti-inflammatory wonder drug that had been recently approved for animals. The diclofenac in one cow carcass can kill several vultures within days. India banned the drug's manufacture, but it's still widely used (and is newly licensed in Tanzania). With only a few thousand vultures left in India, the Bombay Natural History Society is breeding birds in captivity. Meanwhile, the die-off has had other serious consequences. Feral dogs are finding more carrion and multiplying—and they can carry rabies. —Helen Fields



White-rumped vultures and two other species are now nearly extinct in India.

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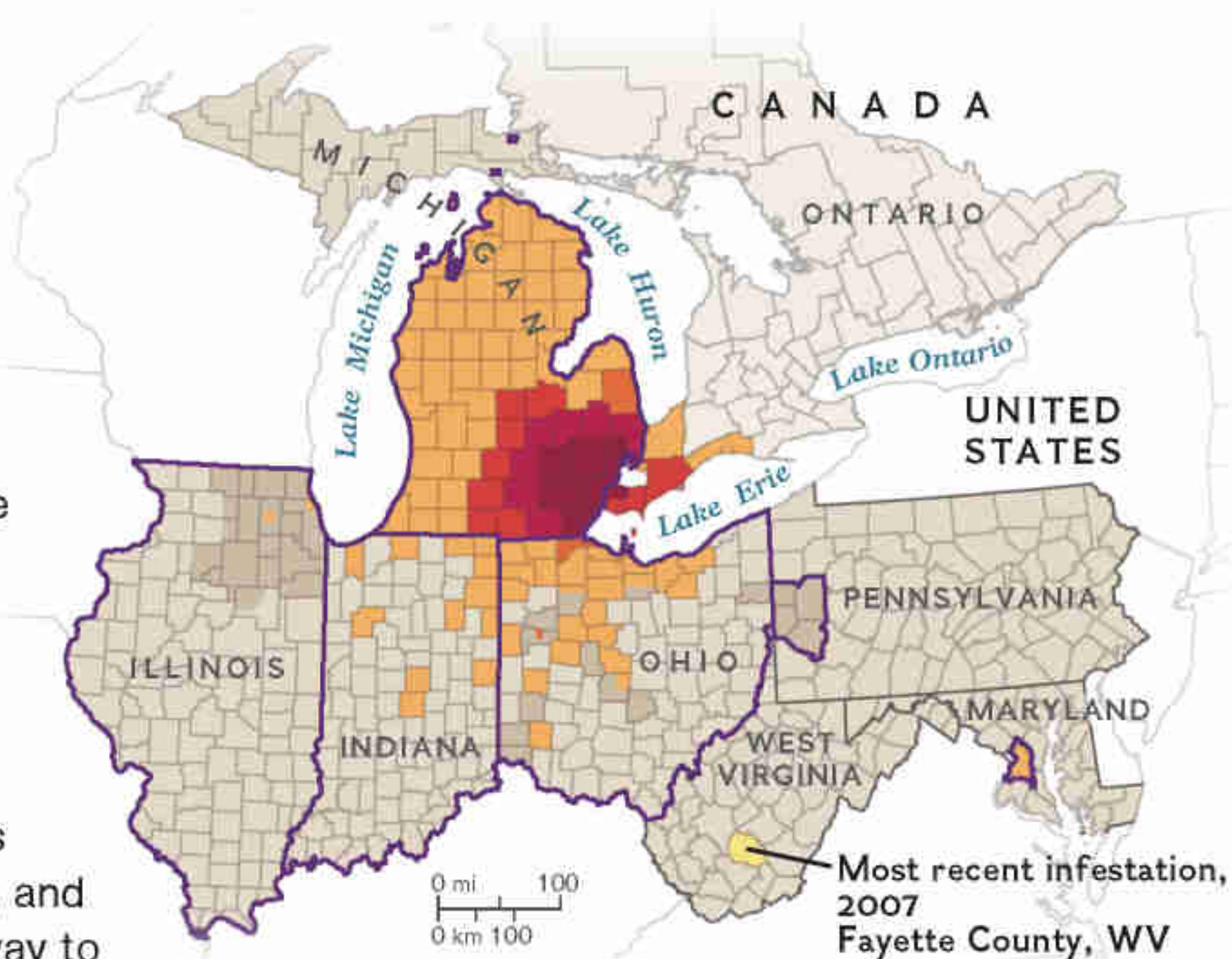
SIEMENS

Bugged Bats

As the steroid scandal eats away at one side of major league baseball, a ravenous insect eats away at another. Emerald ash borers (inset) are chomping across the upper Midwest, killing ash trees that provide choice timber for



millions of baseball bats each year. This alien invader—native to eastern Russia and northern Asia—was first detected in Michigan and Canada in 2002, probably having spread to the Great Lakes in wooden crates aboard cargo ships. Since disembarking, the bug has swept across seven states, hitchhiking on nursery trees, logs, and firewood. With scientists still searching for a way to beat this pest, the federal government has imposed a quarantine in six states—which, if expanded, might tie up baseball-bat manufacturers. “So far, the infestation hasn’t affected bat shipments, but it’s closing in on us,” says Brian Boltz of Hillerich & Bradsby, a Kentucky company that sends 40,000 ash trees a year to its mills. Many pros have switched from ash to stiffer maple bats—for the added pop, they say, not because of the pest. Still, it’s another sign the game on the ground is changing. —Alan Mairson



Emerald ash borer infestation
 — U.S. federal quarantine, as of December 2007
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Year of U.S. or Canadian federal quarantine
 2002 2003 2004 2005 2006



At Louisville Slugger, wooden billets become bats for some of baseball’s biggest stars.

An elderly woman with white hair and a young girl wearing a white hat and a plaid shirt are working together to plant small purple flowers into a large, ornate wooden planter box. The planter box is filled with various colorful flowers, including yellow, red, and purple ones. They are outdoors, with a house and some trees in the background.

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WHERE IN THE WORLD?



Ammo igloos stud the 23,000 acres of Tooele Army Depot, located some 35 miles southwest of Salt Lake City.

Boom Town America's combat troops couldn't do their job without the hundreds of igloos dotting Utah's high desert. All sorts of conventional munitions, from small cartridges to bombs, are stored in the huts. They're part of Tooele Army Depot; established in 1942, it supplies military missions and develops equipment. The Army won't share many details about the igloos. What it will say: Each is about 60 feet long, made of concrete, and covered with soil and grass to smother accidental explosions. Fortunately there haven't been any. But there is a history of intentional blowups: For decades Tooele detonated outdated munitions, rattling homes (and nerves) in nearby Grantsville. In the 1990s the Army began curtailing detonations. So what's the fate of old ammo nowadays? A spokeswoman says Tooele is "heavy into recycling." —*Oliver Uberti*



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Clad in space suits, would-be astronauts trek across Canada's Devon Island.



Mars, Eh? The problem on Mars won't be boredom. It won't be lack of oxygen. Astronauts will face a greater risk from working too hard or wrecking their rovers. These are among the findings from mock missions on Devon Island, a barren rock in the Canadian Arctic where cold and isolation approximate what explorers might find on the red planet. Last summer seven volunteers from the U.S. and Canada spent four months on Devon in the longest such simulation. Funded by the nonprofit Mars Society, the volunteers lived in a cramped, two-story cylinder. They ate freeze-dried food and did experiments. They donned space suits to work outside. They showered infrequently. The test pointed out the vast amounts of water a mission to Mars will need, and how daunting stress can be in an alien environment. One earthly obstacle astronauts won't face: prowling polar bears. —Neil Shea



DEVON ISLAND DETAIL

- Earth's largest uninhabited island is roughly 20,000 square miles.
- About 39 million years ago a large meteorite punched a crater 14 miles wide in the island.
- The cold, dry environment is similar to—but not as extreme as—the one on Mars.

Emergency

If you've been here before,
PLAVIX could help keep you from coming back.

PLAVIX can help save lives for those who've had a heart attack caused by a completely blocked artery.



Clots that block off arteries are the main cause of heart attack. And now that you've had a heart attack you are at a greater risk of having another that can be fatal. That's why your doctor may put you on PLAVIX along with your

other heart medicines. Taking PLAVIX with your other heart medicines goes beyond what other heart medicines alone can do to keep blood platelets from sticking together and forming dangerous clots.



IMPORTANT INFORMATION: If you have a stomach ulcer or other condition that causes bleeding, you should not use PLAVIX. When taking PLAVIX alone or with some other medicines including aspirin, the risk of bleeding may increase so tell your doctor before planning surgery. And, always talk to your doctor before taking aspirin or other medicines with PLAVIX, especially if you've had a stroke. If you develop fever, unexplained weakness or confusion, tell your doctor promptly as these may be signs of a rare but potentially life-threatening condition called TTP, which has been reported rarely, sometimes in less than 2 weeks after starting therapy. Other rare but serious side effects may occur.

Ask your doctor how PLAVIX can help increase your protection against future heart attack, stroke, and even death. Or visit www.plavix.com or call 1-800-269-8927.

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WHO IS PLAVIX FOR?

PLAVIX is a prescription-only medicine that helps keep blood platelets from sticking together and forming clots.

PLAVIX is for patients who have:

- had a recent heart attack.
- had a recent stroke.
- poor circulation in their legs (Peripheral Artery Disease).

PLAVIX in combination with aspirin is for patients hospitalized with:

- heart-related chest pain (unstable angina).
- heart attack.

Doctors may refer to these conditions as ACS (Acute Coronary Syndrome).

Clots can become dangerous when they form inside your arteries. These clots form when blood platelets stick together, forming a blockage within your arteries, restricting blood flow to your heart or brain, causing a heart attack or stroke.

WHO SHOULD NOT TAKE PLAVIX?

You should NOT take PLAVIX if you:

- are allergic to clopidogrel (the active ingredient in PLAVIX).
- have a stomach ulcer
- have another condition that causes bleeding.
- are pregnant or may become pregnant.
- are breast feeding.

WHAT SHOULD I TELL MY DOCTOR BEFORE TAKING PLAVIX?

Before taking PLAVIX, tell your doctor if you're pregnant or are breast feeding or have any of the following:

- gastrointestinal ulcer
- stomach ulcer(s)
- liver problems
- kidney problems
- a history of bleeding conditions

WHAT IMPORTANT INFORMATION SHOULD I KNOW ABOUT PLAVIX?

TTP: A very serious blood condition, called TTP (Thrombotic Thrombocytopenic Purpura) has been rarely reported in people taking PLAVIX. TTP is a potentially life-threatening condition that involves low blood platelet and red blood cell levels, and requires urgent referral to a specialist for prompt treatment once a diagnosis is suspected. Warning signs of TTP may include fever, unexplained confusion or weakness (due to a low blood count, what doctors call anemia). To make an accurate diagnosis, your doctor will need to order blood tests. TTP has been reported rarely, sometimes in less than 2 weeks after starting therapy.

Gastrointestinal Bleeding: There is a potential risk of gastrointestinal (stomach and intestine) bleeding when taking PLAVIX. PLAVIX should be used with caution in patients who have lesions that may bleed (such as ulcers), along with patients who take drugs that cause such lesions.

Bleeding: You may bleed more easily and it may take you longer than usual to stop bleeding when you take PLAVIX alone or in combination with aspirin. Report any unusual bleeding to your doctor.

Geriatrics: When taking aspirin with PLAVIX the risk of serious bleeding increases with age in patients 65 and over.

Stroke Patients: If you have had a recent TIA (also known as a mini-stroke) or stroke taking aspirin with PLAVIX has not been shown to be more effective than taking PLAVIX alone, but taking aspirin with PLAVIX has been shown to increase the risk of bleeding compared to taking PLAVIX alone.

Surgery: Inform doctors and dentists well in advance of any surgery that you are taking PLAVIX so they can help you decide whether or not to discontinue your PLAVIX treatment prior to surgery.

WHAT SHOULD I KNOW ABOUT TAKING OTHER MEDICINES WITH PLAVIX?

You should only take aspirin with PLAVIX when directed to do so by your doctor. Certain other medicines should not be taken with PLAVIX. Be sure to tell your doctor about all of your current medications, especially if you are taking the following:

- aspirin
- nonsteroidal anti-inflammatory drugs (NSAIDs)
- warfarin
- heparin

Be sure to tell your doctor if you are taking PLAVIX before starting any new medication.

WHAT ARE THE COMMON SIDE EFFECTS OF PLAVIX?

The most common side effects of PLAVIX include gastrointestinal events (bleeding, abdominal pain, indigestion, diarrhea, and nausea) and rash. This is not a complete list of side effects associated with PLAVIX. Ask your doctor or pharmacist for a complete list.

HOW SHOULD I TAKE PLAVIX?

Only take PLAVIX exactly as prescribed by your doctor. Do not change your dose or stop taking PLAVIX without talking to your doctor first.

PLAVIX should be taken around the same time every day, and it can be taken with or without food. If you miss a day, do not double up on your medication. Just continue your usual dose. If you have any questions about taking your medications, please consult your doctor.

OVERDOSAGE

As with any prescription medicine, it is possible to overdose on PLAVIX. If you think you may have overdosed, immediately call your doctor or Poison Control Center, or go to the nearest emergency room.

FOR MORE INFORMATION

For more information on PLAVIX, call 1-800-633-1610 or visit www.PLAVIX.com. Neither of these resources, nor the information contained here, can take the place of talking to your doctor. Only your doctor knows the specifics of your condition and how PLAVIX fits into your overall therapy. It is therefore important to maintain an ongoing dialogue with your doctor concerning your condition and your treatment.

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PLA-OCT07-B-Ae

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 **Bristol-Myers Squibb**

100-Year-Old San Francisco Mint Gold Saved From Destruction



Actual size is 21.6 mm

The San Francisco "S" mintmark

A century ago in 1906, San Francisco was devastated by a massive earthquake. On that date the mint ceased forever production the historic Lady Liberty \$5 "Half Eagle" gold piece. It was the end of an era for the coin that had been made of 90% pure gold with the famous "S" mintmark since the California Gold Rush. Yet for even those coins that survived the calamity of the terrible 1906 earthquake, an even worse fate lay ahead...

Reserved from Massive Meltdown in 1934

In 1934, U.S. gold coins were officially recalled by the Federal Government and melted down into 100-ounce and 400-ounce gold ingots. An estimated 95% of all the San Francisco Liberty \$5.00 gold coins were lost for forever.

Surviving "S" Mint Liberty gold coins, few and far between, are increasingly valued by today's collectors. Now, GovMint.com has authorized the limited release of 100-year-old, "S" Mint \$5.00 gold "Half Eagles" saved from the San Francisco earthquake and subsequent official U.S. Treasury meltdown. These coins are dated 1866 to 1906 and struck in .900 fine (90% pure) gold. They are collector quality, with a numismatic grade of Extremely Fine. During this limited release, these authentic 100 year old gold coins may be acquired for as little as \$329 each (compare with current advertisements from retail coin dealers of up to \$365 each).

The History of The West In Your Hands

The history of the American West lives on in these glittering gold coins. The San Francisco Mint was built from the California Gold Rush and minted gold delivered from the miners. San Francisco and the western states grew out of the gold and silver strikes and the immigrants who came from all across the land to build a new future. The images of Miss Liberty and the American Eagle on each U.S. \$5.00 gold coin symbolize our nation's freedom, strength and faith. These precious and enduring coins are becoming more precious and sought-after with each generation and will become a valuable legacy for you and your loved ones.

Order Before They Are Gone

The supply of 100-year old San Francisco "S" Mint \$5 Half-Eagle XF gold coins is limited. Due to huge changes in the value of gold (a 62% increase in the last two years alone) no one can predict the future value of this coin. Therefore, listed prices cannot be guaranteed and are subject to change without notice. Your immediate action is requested—Call the toll-free number 24 hours a day, 7 days a week.

Money-Back Satisfaction Guarantee.

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**MONEY-BACK
SATISFACTION GUARANTEE**

Member Better Business Bureau **BBB**

Dwindling Bow Tree Critics praise the “exquisite poetry” of virtuoso Joshua Bell’s violin. But the Stradivarius wouldn’t sound as good without his 200-year-old, \$40,000 bow. “When I picked it up, it really brought out colors from the instrument that other bows didn’t.” Fine bows like Bell’s are made from pernambuco, the wood of the *pau brasil* tree, which gave Brazil its name. Centuries ago, its heartwood was used to make a red dye popular in Europe; European bowmakers took notice of pernambuco’s strength and flexibility. But the tree has become rare as Brazil’s population has encroached on coastal forests and harvested pernambuco for fence posts and other uses. Last June pau brasil received protection under CITES, the treaty on international trade in endangered species. Bowmakers are working to conserve the tree and also looking for alternative woods. Fortunately for Joshua Bell, the listing only restricts trade in raw materials, so string players won’t need permits to travel with their bows. —Helen Fields



From top: *pau brasil* seedlings; bristly fruits; wood for bows, marked with chalk; shavings on a bowmaker’s bench. Left, a cello bow made by craftsman Robert Morrow.



Lowering its suspension 15 millimeters
raised the bar exponentially.



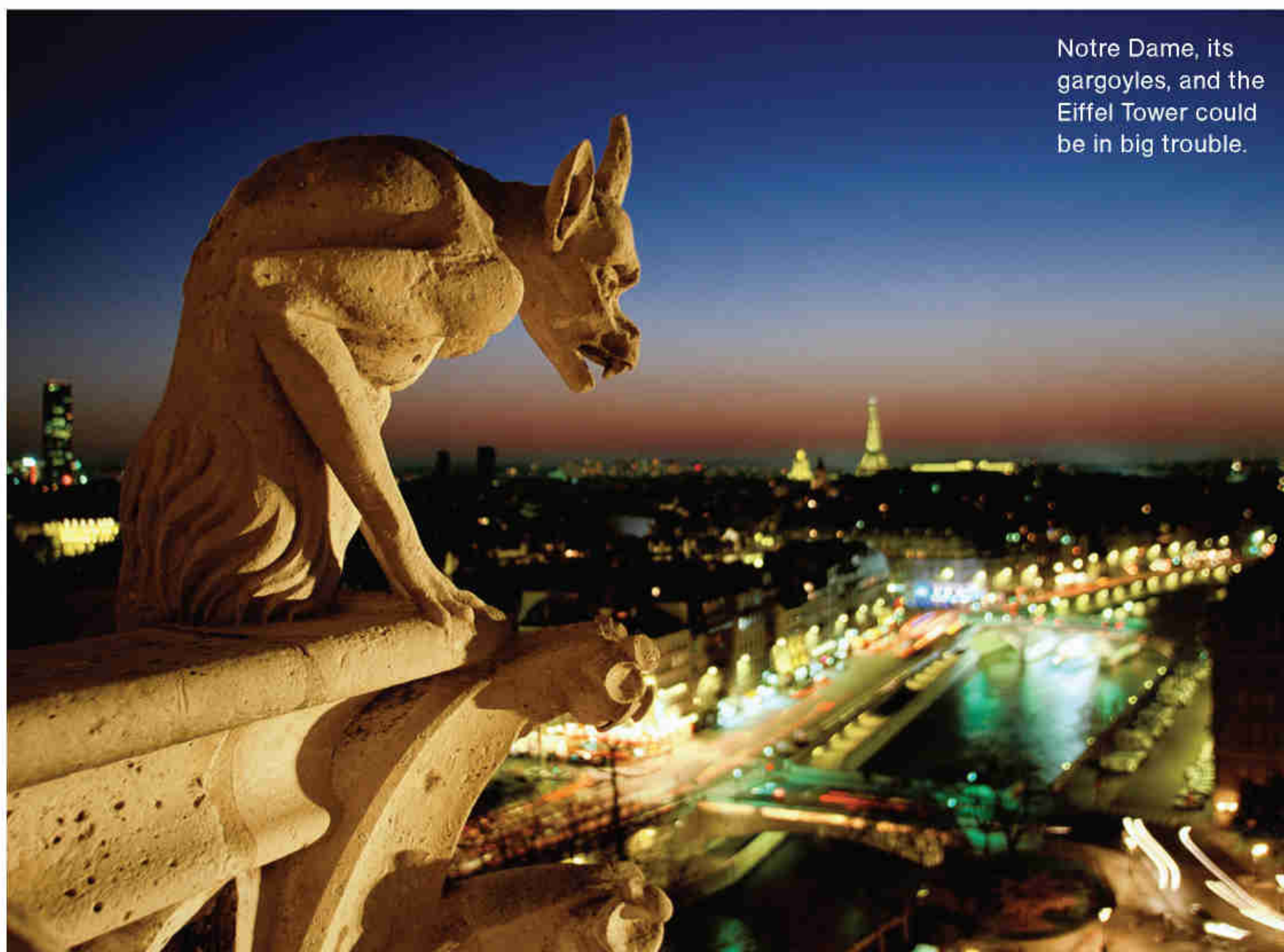
Mercedes-Benz

The 2008 C-Class

Precision. At Mercedes-Benz, it's calculated to the millimeter. Fifteen tiny ticks lower on our C-Class means more precise handling in tight curves. After all, it may not seem like a lot, but a few millimeters closer to the ground is a detail that puts us well above others.

MBUSA.com

2008 C 300 shown with optional Obsidian Black metallic paint, Panorama Roof and Premium 2 Package. ©2008 Mercedes-Benz USA, LLC.
For more information, call 1-800-FOR-MERCEDES, or visit MBUSA.com.



Notre Dame, its gargoyles, and the Eiffel Tower could be in big trouble.

Landmarks at Risk Neither war nor looters nor natural disasters could do them in. But now Europe's landmarks face a threat that may be even tougher to weather: climate change. According to Peter Brimblecombe, an atmospheric chemist who worked on a recent European Union-funded environmental study



called Noah's Ark, the next century could be problematic for the Continent's cultural gems. Besides such catastrophic possibilities as storms and floods, a host of less dramatic elements could hasten wear, tear, and surface erosion. One worry is salt, which crystallizes and builds up when there's less humidity. That could mean a kick in the buttresses for Gothic wonders like the Cathedral of Milan (inset). Another is temperature fluctuations; thermal shock could blight the marble monuments of the Mediterranean. And more moisture up north could spell big trouble in the form of stone-eating microbes, metal corrosion, fungi, and lichen. All of which means you may want to hurry up and take that grand tour. —Jeremy Berlin

MONUMENTAL WOES

What's eating Europe's prize sites—and what isn't?

- **Salt crystallization** weathers away stone.
- **Stone-eating microbes** don't really eat stone, but their acidic excretions do.
- **Thermal shock** expands, contracts, and cracks marble surfaces.
- **Torrential rains** flood gutters, penetrate porous building materials.
- **Rising temperatures** in some areas mean less frost weathering—good news at last.



frogs

What would
fairy tales be
without them?

At first, scientists weren't sure what was happening. They thought perhaps the frogs they had always seen had just disappeared for a season or two. But there would be no happy ending. The frogs that had disappeared weren't coming back. In the past 20 years, more than 100 species of amphibians have become extinct. As many as half of the world's 6,000 amphibian species are threatened, a large number by a fungal disease called chytrid (KIT-rid).

In the balance of nature, frogs play a starring role. They eat insects that carry disease. They help protect the fragile ecosystems of the places they call home. But now, the only hope of saving frogs is to rescue them — capture them in the wild and take them into protective custody. It's a pioneering undertaking by a coalition called Amphibian Ark.

The Year of the Frog

The world's leading conservation organizations have joined together to declare 2008 the year of the frog. They hope to raise awareness and funding to save dozens of amphibian species from immediate extinction. Every person can play a role in "2008 Year of the Frog," according to Amphibian Ark, which coordinates the efforts of zoos and scientists around the world. To find out more, go to www.amphibianark.org.



The makers of Clorox® products are proud to be the first official corporate sponsor of 2008 Year of the Frog. Clorox® Regular-Bleach is used every day in the battle to save frogs. For more on how Clorox is helping, go to www.savethefrogs.com.

Green within reach



New Green Works™ cleaners from Clorox — the natural choice

For years, green and easy just didn't go together. Most green cleaners either weren't very green or weren't very effective cleaners, or both. No wonder consumers gave up. Finally, big businesses are getting the message.

With its new plant-based Green Works™ line of products, Clorox has brought cleaning to green: The products are 99 percent natural and work as well as or better than conventional cleaners. And the price is right.

Never thought of putting Clorox and green in the same sentence? As surprising as it sounds, it's a good sign. "If we're serious about living greener, we need big companies like Clorox involved and committed," says Jessica Buttner, marketing director for Green Works™ products.

The U.S. Environmental Protection Agency's Design for the Environment Program partners with leading

companies to make safer products for consumers and the environment. Design for the Environment recognition means that the product uses the safest possible ingredients that also ensure the product performs well. (www.epa.gov/dfe)

After nearly 100 years in business, Clorox certainly knows about cleaning, and with ingredients derived from lemon, corn and coconut, Green Works™ cleaners are a natural.



Plant-based Green Works™ products are now available at The Home Depot® stores and online.

Every product with The Home Depot's Eco Options label, including Green Works™ products, has less of an impact on the environment than competing products. For more information, visit www.homedepot.com/ecoptions.

Just what the world needs,
another cleaning product.

It's made from plants, and cleans as well as traditional cleaners.

Green Works™ is exactly what the world needs.

Finally,





It's hard to find your litter box if you can't smell it.

freshstep.com



A Mouse for All Seasons

Call the Jackson Laboratory in Bar Harbor, Maine, and you may hear: "All of our representatives are assisting other customers." Not unusual—till you consider that the flood of calls to the nonprofit is from people ordering mice. And not just any mice. These are bred with specific genetic makeups, each a model for a human disease or disorder—everything from bone loss to blindness, Alzheimer's to arthritis. Over 75 years the lab's catalog has grown to include more than 3,300 strains. Mouse farming gained new impetus from the recent sequencing of the human and mouse genomes, which confirmed how genetically similar the two species are (the differences have to do with when and where genes are activated). Last year Jackson shipped 2.4 million mice to 16,000 researchers worldwide. The most popular strain—the Black 6 (above), developed in 1921—has been used to study everything from diabetes to obesity, and has even traveled aboard the space shuttle. That's a mouse worth holding the line for. —*Peter Gwin*

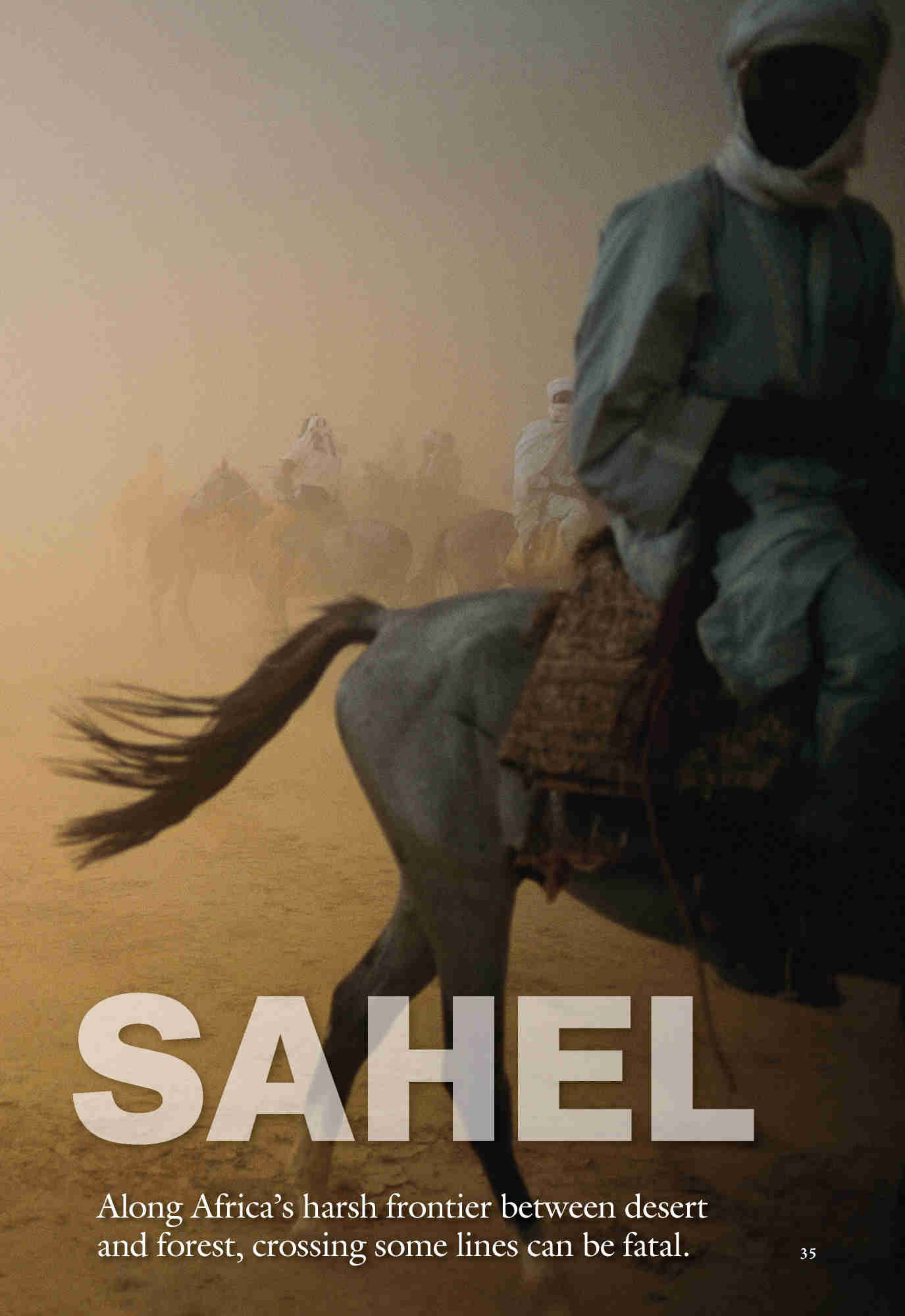
BY PAUL SALOPEK

PHOTOGRAPHS BY PASCAL MAITRE

In a blur of dust turbaned riders gather to watch a race in Abéché in eastern Chad. A thousand years ago men on horseback carried Islam and Arab culture across the vast, dry lands bordering the Sahara.



LOST IN THE



SAHEL

Along Africa's harsh frontier between desert and forest, crossing some lines can be fatal.

NIGER | Swallowing all but the tallest trees, dunes have buried cropland near the city of Goudoumaria, where a herder follows goats in search of forage. Reduced rainfall has withered vegetation and dried up wells in parts of southern Niger, forcing villagers to move. The Sahel experienced droughts in the 1970s and '80s, and although rainfall has increased since the 1990s, a decades-long dry spell continues.







NIGER | Riding a mountain of belongings, migrants who had left Niger for Libya return home in the face of antiforeign sentiment. The Sahel was once the center of a camel-borne trade that took slaves, ivory, and gold to Europe and the Middle East, but it now lies on the margins of the world's economy. Many of the region's young men have gone to wealthier countries such as Libya and Algeria to find work.

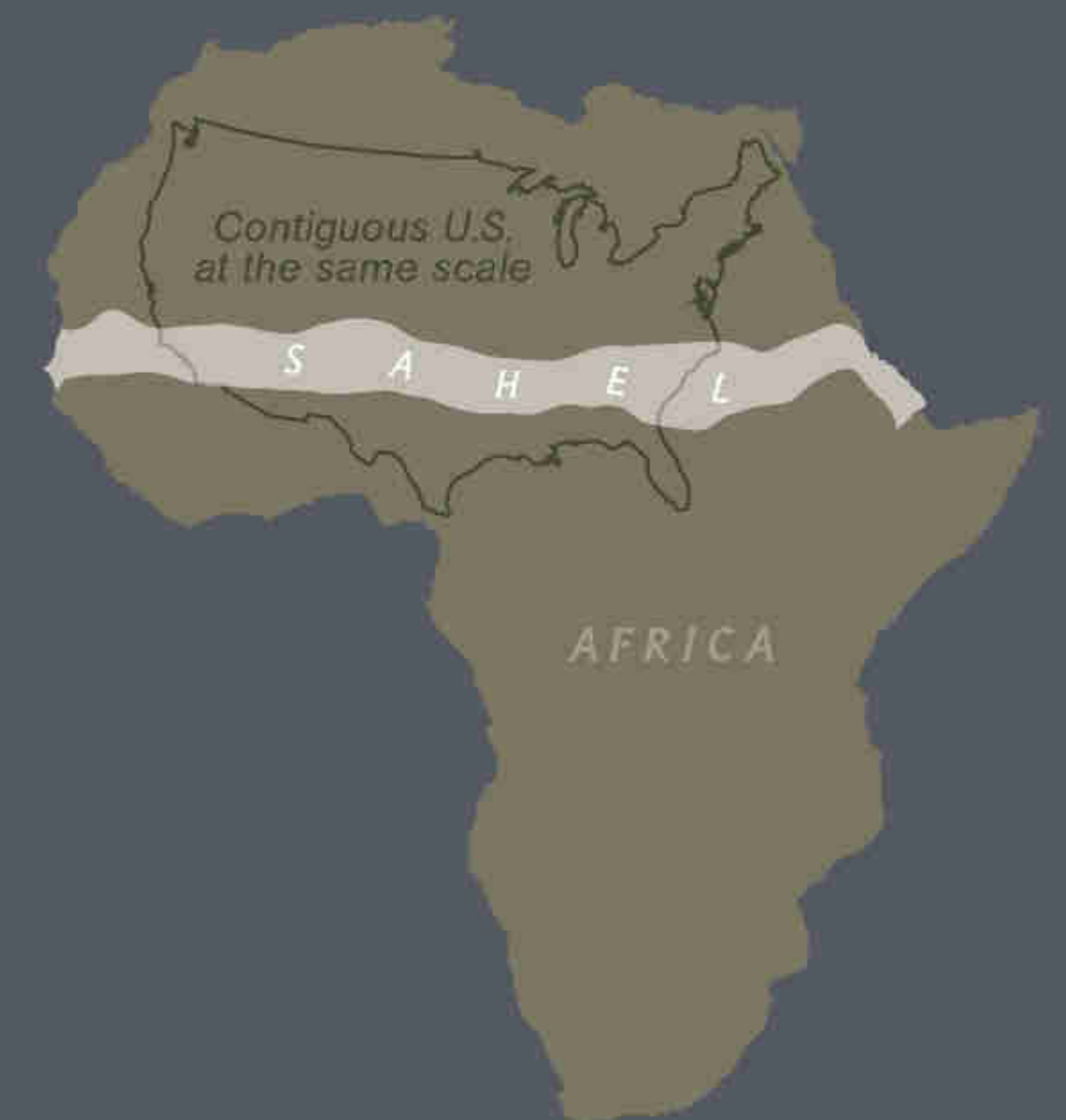


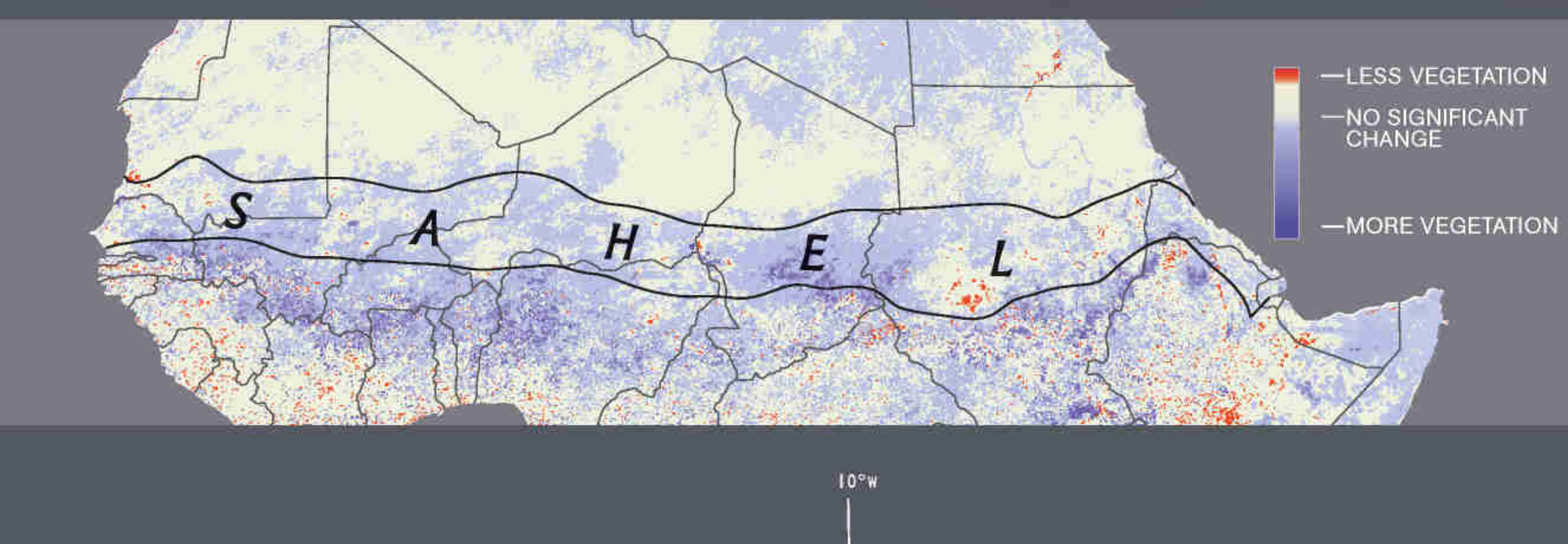
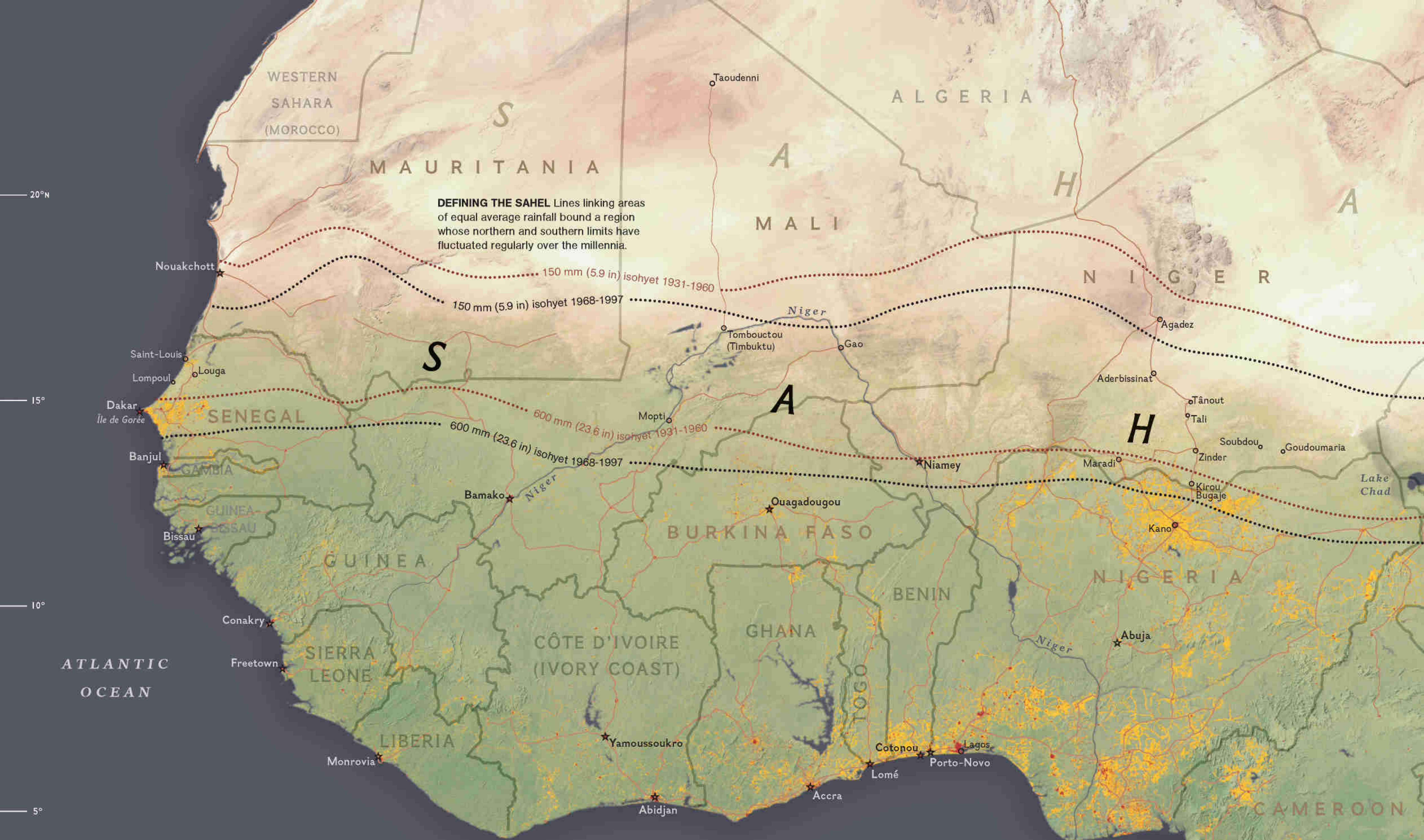
SENEGAL | The Sahel ends at the Atlantic in Dakar, where open land may become a highway to relieve congestion in the densely populated capital. On the beach, fishing boats deliver catches by day and leave by night loaded with migrants risking a crossing to the Canary Islands—way station to Europe. Hundreds die every year, and though Spain and Senegal have increased air and sea patrols, the exodus goes on.





NIGER | Shoveling out a road near the village of Tali seems a hopeless task, but young volunteers earn tips from the few drivers who use the route—one way to get cash in this poor, mostly rural country where jobs are scarce. Despite such smothering sands, land-locked Niger is working to improve its roads, with help from Western donors and OPEC.





UNEXPECTED GROWTH Ground surveys over time reveal that the quality of land in the Sahel has deteriorated during the past 50 years—fewer trees and shrubs and thinner, less productive soils. But satellite data since 1982 show areas where vegetation—natural and cultivated—has increased more than expected from increases in rainfall. This may be partly because rising levels of carbon dioxide in the air have promoted plant growth, which enhances the soil's ability to hold water, leading in turn to more growth. The data also suggest that in some scattered areas vegetation has decreased more than expected. Likely causes: tree cutting, overgrazing, overcultivation, and erosion.



Author was captured
in this area Aug. 2006

Extent of
the Sahel
1968-1997

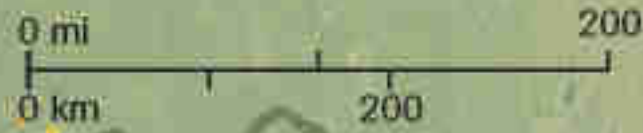
Extent of
the Sahel
1931-1960

SHIFTING RAINS

THE SAHEL | In this transitional zone at the edge of the Sahara, Earth's largest desert, rainfall varies from 6 inches a year in the dry north to 24 in the wetter south. Through much of the late 20th century, rising ocean temperatures altered rainfall patterns, and the precipitation didn't reach as far north (black dotted lines) as it did from the 1930s to 1960 (red lines). After the late 1960s the Sahel moved south and became drier. Green lands turned barren, nomads lost their herds, and in the northern Sahel, desert dunes, no longer anchored by vegetation, invaded some villages. Recently, rainfall has increased, and in many places, vegetation too. Scientists project that global warming will cause precipitation to become spottier and less reliable, with heavy and light rains at different times and in different places.

Population Density
(persons per square km)

- More than 1,000
- 100 to 1,000



MARTIN GAMACHE, NG STAFF
SOURCES: ISAAC FIELD; SHARON E. NICHOLSON; STEPHEN D. PRINCE; GRAY TAPPAN; OAK RIDGE NATIONAL LABORATORY LANDSCAN 2006

DEMOCRATIC REPUBLIC OF THE CONGO

UGANDA
Kampala

20°

30°



SUDAN | After a skirmish with government forces, Darfur rebels of the Sudanese Liberation Army (SLA) regroup at a vehicle carrying weapons and a bundle of amulets for magical protection. The SLA has fractured into factions that attack civilians and each other as often as they fight the Sudanese Army.

EDITOR'S NOTE | When journalist Paul Salopek entered Sudan to report on Darfur, he was captured by guerrillas, turned over to the government, and jailed as a spy. After five weeks he was released, following negotiations by *National Geographic* and the *Chicago Tribune* and intervention by Governor Bill Richardson of New Mexico. Salopek later returned to the Sahel to finish the story.

DARFUR—THE ROAD TO FURAWIYA

The road was not really a road.

Its two ruts led into Darfur, to the war in western Sudan, from the unmarked border of Chad. So much of the Sahel was like this—unmapped, invisible, yet a boundary nonetheless. The land stretched away in a monotony of gravel pans and dried grasses so translucent—so brittle—they seemed made of blown glass. The iron horizons never budged. Yet we were crossing boundaries with every passing hour, mostly without seeing them.

After I was arrested and imprisoned in Darfur, an American soldier told me, shaking his head in disgust, “You fly over this place and all you see is miles and miles of nothing.” But that was an outsider’s delusion. Every outcrop and plain was parsed by unseen tangents, lines, ghostly demarcations. They portioned off the claims of tribes, individuals, clans. They bulged and recoiled according to war and season. No-go zones encircled water holes. Certain unseen lines, *masars*, dictated the migration routes of nomads. There was nothing haphazard about any of this. To cross one line or to venture too far from another might invite retribution, even death. And that was the ultimate line of them all in the Sahel: the one between knowing and ignorance.

The Sahel itself is a line.

The word means “shore” in Arabic, which implies a continental margin, a grand beginning and a final end. Stretching across northern Africa roughly along the 13th parallel, the Sahel divides—or unites, depending on your

**WOMEN HAVE BEEN
SINGLED OUT FOR
MAXIMUM VIOLENCE IN
DARFUR. MASS RAPES
BY THE JANJAWEEED HAVE
BEEN DOCUMENTED.
WOMEN HAVE BEEN
BURNED ALIVE.**



CHAD | Chased from her village by fighting, a woman digs for firewood in a displaced persons' camp near Goz Beïda. The area never had many trees, but now, with an influx of tens of thousands of Sudanese refugees and Chadians fleeing attacks by ethnic militias, roots are all that's left to burn.

philosophical bent—the sands of the Sahara and Africa's tropical forests. It is a belt of semi-arid grassland that separates (or joins) Arabs and blacks, Muslims and Christians, nomads and farmers, a landscape of greens and a world of tans. Some 50 million of the world's poorest, most disempowered, most forgotten people hang fiercely on to life there. And for 34 days in Darfur we joined their ranks.

There were three of us.

Idriss Anu drove the Toyota truck that would be stolen by militants. Daoud Hari was the translator, and for this he would eventually pay with severe beatings. We were en route to the village of Furawiya when the pro-government guerrillas rose silently from the grass.

"Stay in the car," Daoud said.

But it was already too late. Even as the gunmen sauntered up, their hair matted in dreadlocks and their chests slung with small blackened things that looked like dried ears but which were Koranic amulets, we still hadn't grasped that we had crossed a threshold where it no longer mattered what passport you carried, that you were young and loved, that your skin was supposedly not of a torturable color, or that you were a noncombatant. Words had lost all currency as words, and by the time the grinning teenager with the Kalashnikov reached for my door handle, we were condemned to live and die according to choices made by others. We had become truly Sahelian.

The Sahel is a line.

But it is also a crack in the heart—a tightrope, a brink, a ledge. See how its people walk: straight-backed on paths of red dust, placing one foot carefully before the other, as if balanced upon a knife edge. The Sahel is a bullet's trajectory. It is the track of rains that fall but never touch the sand. It is a call to prayer and a call for your blood, and for me a desert road without end.

GAGA REFUGEE CAMP, CHAD

My journey began among refugees in eastern Chad. This is where I met George Bush's father.

Bush tyrannized his family's small plot of

sand. He threw his mother's battered dishes to the ground, pulled on visitors' noses, and scampered away giggling. He got away with this because he was an only son. His elder sister, age four, despised him. Bush was fat-cheeked and two. "Boosh!" the refugees cooed. "Boosh-ka!" He was clearly a great camp favorite. This was in the Gaga settlement, where more than 7,000 Darfuris lived and died under UN canvas.

"Only George Bush can stop the Arabs in our land," said Bush's papa, Ahmed Juma Abakar. He corralled the boy in his lap. "When he grows up, he will help kill them."

Multiple lines of identity were braided through Abakar. He was a coffee-colored African with a puff of white hair on his chin. He was a Masalit, a member of one of the African farming tribes driven out of Darfur at gunpoint by the janjaweed, the Arab nomads armed by the Arab-dominated government of Sudan. He detested Arabs. Yet he himself spoke Arabic. He also served sugary tea in shot glasses like an Arab, wore a white Arabic robe, and prayed five times a day toward Mecca. I, too, find this puzzling.

The war in Darfur has killed at least 200,000 people and displaced more than two million. It may be the first genocide of the new century. But it also happens to be one of several similar, if smaller, conflicts boiling across the Sahel. Chad, Niger, Mali, Nigeria, and Senegal—low-intensity battles smoldered in each nation I visited. Niger was expelling its Mahamid nomads. Tuaregs were ambushing African soldiers in Mali. These clashes were parochial, obscure, yet part of an overarching quarrel: the eternal struggle over grass, water, and soil between pastoralists and settled peoples. Viewed this way, the Sahel represents the oldest killing field in human history. In the Sahel, Cain is still trading blows with Abel.

In Darfur the violence is infamous because

Sudan's government had cynically armed one side—the Beni Husseins, Ereigats, and other Arab herders—against rebellious African farmers such as the Masalits and Furs. These two rivals, both Muslim, had earlier evolved a complex entente. When a farmer speared a nomad's camel, elders docked part of his harvest. The plaintiff usually claimed the grain in a hungry year. It was an antique food bank system. Murder between tribes was settled with a sliding scale of blood money—a hundred camels for a man, fifty for a woman.

A ten-pound machine with eleven moving parts has erased this legacy.

The flood of cheap Kalashnikov rifles into Darfur has devalued individual responsibility in warfare. It has undercut the tribal authorities. Young men who once sang songs to their favorite cows now serenaded their guns: "The Kalash brings cash / Without a Kalash you're trash."

"We used to get along," Abakar said. "The Arabs would graze their camels on our fallow fields. They were my father's friends."

I asked when Arabs and Africans would be brothers again. Abakar looked at me with genuine incredulity. He then tuned his transistor radio to the BBC. The Israelis were bombing Lebanon. "*Allah-u akbar!*" the old Muslim tribesman said, cheering on the Israel Defense Forces. He raised George Bush's chubby little arms in triumph.

DARFUR—TOWÉ VILLAGE

On our first night in Darfur the gunmen forced Idriss and Daoud into a pickup truck and drove them off into the moonlight. They tortured them out there, tied to a thorn tree for three days. Me they pummeled without enthusiasm inside an abandoned hut in the burned-out village of Towé. Between sessions, I lay trussed on my belly, breathing hard against a dirt floor that smelled of rancid butter. I squinted out a brilliant doorway at two women.

They were planting sorghum in a dry wadi.

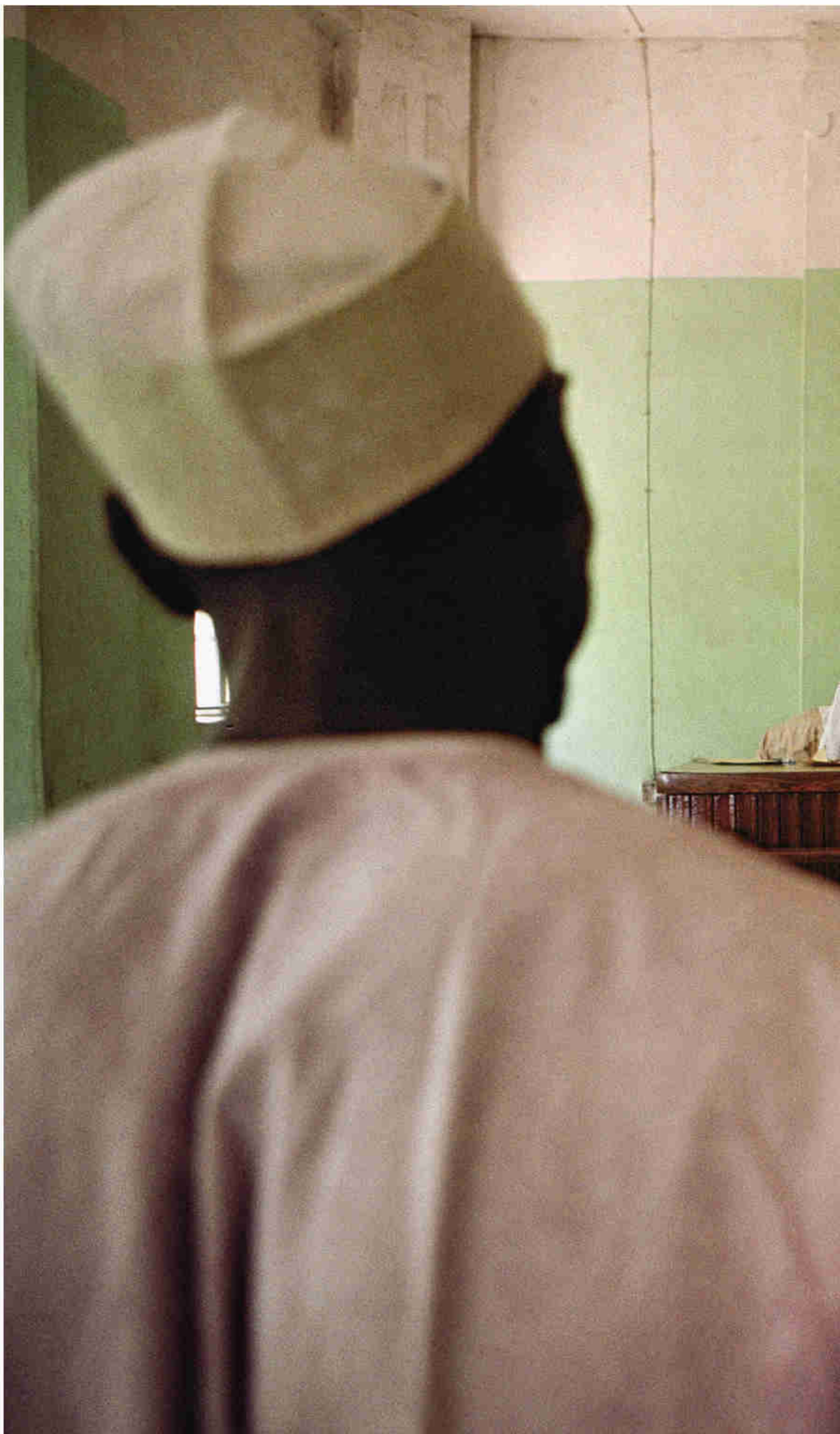
The women's work appeared rudderless. They planted their seeds in lines that wriggled across the field, nudged here and there

Paul Salopek is a Pulitzer Prize-winning foreign correspondent with the Chicago Tribune. Pascal Maitre photographed oil in Africa in September 2005.





NIGER | Huddled in the morning chill, students at a Koranic school in Goudoumaria prepare to learn the Sahel's mystical brand of Sunni Islam, mixing Sufi and African traditions. Lacking books or paper, they write verses from the Koran on wooden tablets in washable ink. When classes end, children who have come from distant villages to study with the school's marabout, or holy man, beg for alms for food.



NIGERIA | A sharia court efficiently settles a land dispute in Kano, a city on the Sahel's southern border whose Muslim majority lives under strict Islamic law. After years of corrupt and bureaucratic secular rule, most residents welcomed Kano state's imposition of sharia in 2000. But minority Muslim sects, human rights advocates, and Christians, especially those who could no longer sell alcohol for a living, protested.



by whims of conversation. The older woman swerved whenever she told jokes, and her seed rows lurched like cardiograms. She giggled into her hands often, and I decided she must be mad. The younger one was more solemn. She toiled briskly, with a sense of purpose, as if engaged in a race, and her planting was much straighter. A tiny child crawled at her side, trying to eat the seed grain. The women labored like this all day. Then, late in the afternoon, they quarreled, and their plantings veered apart in rancor.

It occurred to me that the women were doing more than growing food. They were sowing their autobiographies.

Sex jokes, village gossip, little wisps of song, rebukes to children—all of it lay scribbled in the eccentric lines of their crops.

Women have been singled out for maximum violence in Darfur. Mass rapes by the janjaweed are systematic and well documented. As part of a Sudanese campaign of ethnic cleansing, women have been burned alive, shot, bayoneted, and dumped down wells. These stories, too, would be recorded in their fields. Lying in the hut, I imagined flying low over the savannas of Darfur and reading the women's lives inscribed in plots of millet, peanuts, and sorghum. (See that row of melons ending abruptly at midfield? A Fur grandmother dropped her seed bucket and ran at the sound of approaching hoofbeats.)

In Towé the women were Zaghawa seminomads. The laughing one was named Fatim Yousif Zaite. She wasn't crazy. She was 40, with the burning, clairvoyant gaze of the starving, and a smile that transmitted the innocence of her heart. She brought me gourds of *asida*, a yellow lentil paste she could hardly afford to share. Once, while untied to eat, I grabbed both her dusty hands in mine. She sprang back in fear.

But I only wanted to thank you, Fatim. You will always be with me. The janjaweed may toss your kids into vats of boiling water as they had done to children in another village, and the Sudanese Air Force may bomb your wretched fields as they had before, killing five of your

family members. But for three days in Darfur you were my mother.

KIROU BUGAJE, NIGER

A few months later I was in Niger. I took a bus east. The plains turned lush.

Oxcarts jerked along red roads, hauling mountains of peanuts. Children's laughter dribbled from the high grasses. The *thok-thok-thok* of women pounding millet telegraphed the news of full granaries.

This was a surprise. The Sahel of the imagination is a geographic hunger pang. Cataclysmic droughts scorched northern Africa in the 1970s and 1980s. The most recent famine lashed Niger as recently as 2005. In places, the Sahel continues to starve, to lose ground to the Sahara. On the banks of the Niger River houses lie buried in coffins of sand.

Yet in Niger, a country twice the size of France, researchers have been fascinated to discover that 19,000 square miles of savanna are more vegetated today than 20 or 30 years ago. Similar regeneration of trees, grasses, and bushes appears to be under way in parts of Mali and Burkina Faso. The most precious line in the Sahel has always been green. And lately it has been growing thicker, brighter, more lustrous.

Why?

Ecologists disagree. Some credit global warming, which may be boosting rainfall in sections of northern Africa. Others say years of warfare and chaos in the Sahel have depopulated the African countryside, allowing millions of acres to lie fallow and recover.

At the Hausa village of Kirou Bugaje, the plump chief, Abdurahaman Ademu, had his own explanation: the miraculous leaf of a tree.

"The *gao* improves our yields of millet and sorghum," Ademu said, padding in a white robe and sandals across his tree-shaded fields. "That's why we don't cut the trees down anymore. We plant around them."

The *gao*, an indigenous acacia known to biologists as *Faidherbia albida*, is a nitrogen-fixer like the alfalfa plant. Its leaf litter is rich in nutrients. Twenty-five years ago Ademu and

his people had wiped out virtually every tree within a day's walk to feed themselves in a famine. When their crops failed, they ate the leaves. When the leaves were gone, they razed entire groves to sell for firewood and buy food. But eventually, somewhere, someone remembered that the yields of grain were richer when sown in the fertile shade of surviving gaos. Husbanding wild trees is an ancient practice in the Sahel. Its importance was rediscovered. And from there, the dusty boughs of the gao spread in widening circles of green. Today, without fanfare or mercy concerts, some of the world's poorest farmers are busy stitching huge tracts of the Sahel back together again.

Ademu had three wives. Their names were Zeinahu, Hajara, and Hadjia. He had 20 children whom he called Hey You and This One. He was amused that I found his village beautiful.

At dusk the sky turned orange, and we ate spaghetti drowned in palm oil. The village chirped and squealed like a playground. A white moon rose, and out on the savanna the Fulani nomads were driving their lyre-horned cattle south into Nigeria. They were armed with bows, and some carried broadswords strapped to their backs. There hadn't been a war for years. Drifting to sleep on a prayer rug outside Ademu's family mosque, it was possible to imagine that there was nothing in the world that could not be reclaimed.

DARFUR—GHOST HOUSE PRISON

On the third day of our captivity in Darfur, the gunmen traded Idriss, Daoud, and me to the Sudanese Army for a box of uniforms.

A military helicopter ferried us to El Fasher, the capital of North Darfur, but over Kutum, a loud banging made my muscles grab. We were taking rebel ground fire. Holes blinked open in the fuselage, and a bespectacled officer sitting across from me toppled out of his seat. He rolled around on the deck clawing at his back. It was just a spent round, so he survived. His comrades congratulated him as if he'd won the lottery. But the pilot knew better. After a hard landing at the airport, he jumped

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out of the machine and strode away without looking back.

We were taken to a "ghost house"—one of Sudan's many secret prisons. It was night. A gang of armed toughs screamed into our faces and shoved us against a mud wall. They called us spies and waved their cell phones in front of my eyes. The tiny screens displayed burning towers and lilliputian images of Osama bin Laden. I thought: This is the end. But of course it was only the beginning.

What can be said about those days?

An agent of the *istikhbarat* pawed through my cell's pit toilet each morning, looking for what I can't say. His work was unrewarded because I was on a hunger strike. I was protesting my being held separately, in solitary confinement. I resumed eating on the eighth day when the guards informed me they would force-feed me through a rubber tube. "Like Guantanamo," they said.

My dreams reached malarial intensity. I dreamed of my wife and of running through the wheat north of Mosul where the falling Iraqi shells made the sound of bedsheets ripping and of Don Benito soaking his oak plow in the ranch well in the Sierra Madre. I dreamed of men I had worked with at sea, and where did you go, Edie Brickell, and of *la vida loca*.

During one of the midnight interrogations I spotted a small, spiky animal sniffing its way across the interrogation room floor. It looked

**IT IS A BELT OF SEMI-
ARID GRASSLAND THAT
SEPARATES (OR JOINS)
ARABS AND BLACKS,
MUSLIMS AND CHRISTIANS,
NOMADS AND FARMERS.
IT IS ALSO A CRACK
IN THE HEART.**



NIGERIA | Catholics celebrate Mass in Kano, where Muslims outnumber Christians ten to one. The Sahel marks the southern reach of early Muslim traders, sages, and armies, and the northernmost influence of later European missionaries. Most Christians came to Kano as merchants.

like a hedgehog. I was light-headed with hunger. I had long since run out of things to say. I reached down from my chair.

“Don’t touch the hedgehog,” the colonel said. “OK.”

I reached down again.

“Don’t—touch—the—hedgehog!” It was his pet.

I remember this distinctly: My face felt odd. It was my first smile in ten days.

KANO, NIGERIA

I bumped south in a bush taxi shared with five Fulani nomads and 140 pounds of goat cheese bound for the markets of Nigeria. There were flies.

But for a fly, all of Africa might be Muslim.

Islam galloped across northern Africa by horse and camel while Christian Europe dozed under rulers like Henry the Quarrelsome or Ethelred the Unready. By A.D. 1000 Muslim emissaries—warriors, gold merchants, slavers, scholars, holy men—had planted the green flag of Muhammad and Allah on West African shorelines that wouldn’t see the bleached sails of a Portuguese caravel for four centuries. But the bite of the tsetse fly, *Glossina*, barred the way south. A vector for the blood parasite that causes sleeping sickness, the insect killed off numberless waves of invaders and their horses in its lethal domain, the open woodlands below the Sahara.

Today the tsetses still reign, and the religious border still holds. North of the fly zone, Africa remains austere Muslim; to the south lies a steamy patchwork of Christianity. I encountered this frontier in Kano.

Nigeria’s second largest city lay smeared inside its smog. It received few tourists. It had a reputation for pious mayhem.

Hundreds had died in riots between hot-heads among Kano’s majority Muslims and thousands of minority Christian migrants from Nigeria’s south. Conservative imams encouraged the governor to impose Islamic law, or sharia, on the state—a provocation in secular Nigeria—further inflaming tensions. Street

signs in the city were written in Arabic, and the shops were stocked by Lebanese, Yemeni, and Egyptian traveling salesmen. Motorcycle taxis didn't pick up women: Contact with male drivers was deemed unseemly. A few years ago local officials boycotted a UN antipolio campaign, claiming the vaccines were sterilizing Muslim girls. Polio, which had been almost wiped out in Africa, has since rebounded in Nigeria and is reinfecting surrounding countries.

There is now a black Taliban movement in Kano. One local mullah dubs himself "Kandahar," after the capital of Afghanistan's fanatics.

"I would pay with my blood if I preached inside the Old City," said Foster Ekeleme, the Methodist bishop in Kano's Christian outskirts.

Ekeleme was an Igbo from the southeast who moved with the stiff gait of a retired boxer. He had survived good and bad times between Kano's two great faiths. When I visited, he complained bitterly that his flock was targeted every time the U.S. bombed another Muslim country, but he ended with a plea. "I am hopeful! We Christians and Muslims must learn to coexist. Look—even my night watchman is Muslim!"

It was true. A bored Hausa youth in a white skullcap leaned against Ekeleme's church. The church itself was a fortress of raw concrete circled by a high iron fence. The fence was spiked. All that was missing was a moat. Suspecting that the Christians were speaking from a position of weakness, I consulted a Muslim thinker.

Salisu Shehu was a mellow scholar with droopy eyelids. He taught Islamic studies at Bayero University, where hand-painted billboards exhorted students to Dress Fashionable and Decently.

This is what the professor said: While it was lamentable that people had been burned, hacked, and shot to death for their choice of gods in Kano, the real enemy was poverty. Christian Igbos and Muslim Hausas required jobs. The youths were unemployed, restless. As for Islam in the Sahel, it was neither extremist nor intolerant—it was a very old type of Sufism expounded by the moderate Imam Malik; a nomad's faith

rooted in the traders' live-and-let-live ethic.

"The Sahel isn't a wall between Africans," Shehu said. "It's a crossroads—a bridge."

Today that bridge is groaning. Both the Muslim and Christian populations of Africa have boomed over the past ten years. In the Sahel, where birthrates are among the highest in the world, mosques financed by conservative Middle Eastern states have sprouted in cities and villages. For their part, many of Africa's Christians aren't of the turn-the-cheek Presbyterian sort. Church loudspeakers boom out sermons, preachers bless militias, and several of the riots in Kano were ignited by Christian massacres of Muslims elsewhere in Nigeria. But I never got to meet the extremists.

At five in the morning my hotel phone rang. It was a secret policeman.

"Whatisyourpurposehere?" he demanded.

"Beg your pardon?"

"Youmustcometothelobbynow!"

The tone was clear if the English wasn't. My paperwork was in order. But I panicked. I raced through the list of sources who might have betrayed my presence in Kano, settling on a dour pharmacist who must have Googled my name and pounced on the recent headlines: Sudan Charges U.S. Journalist With Espionage.

With the echoes of cell doors clanging inside my head, I made excuses to the agent in the lobby. I frantically began hiding my notes but only managed to throw out my back lifting the room's refrigerator. I tossed my bag out the second-floor window, eased myself down the exterior sill, and dropped the last nine or ten feet to the ground. My back exploded. So I quit. I gave up. Hobbling into the lobby jackknifed at the waist, with my T-shirt on backward and my surviving notes tucked into my socks, I found the place empty. The policeman had got tired of waiting. This was Nigeria.

By sunrise I had bought all the open seats in an old Peugeot bush cab and left for Mali.

DARFUR—POLICE STATION JAIL

The Russians were very drunk. There were three of them—small, medium, and large—and the





NIGER | Women enlisted by the government of Niger plant shrub branches near Soubdou, securing them with grass to create grids of natural fencing that keep sand from blowing onto land used for crops and grazing (above). For each acre fenced, the group of women receives \$80. Since the drought years in the 1980s, Sahelians have reclaimed damaged land by stabilizing dunes, cultivating trees, building rock walls to halt erosion, and sowing seeds in pits dug to catch rain.





MALI | As they've done for centuries, workers at the Taoudenni mine hack away at salt deposits to extract chunks of the mineral. Camel caravans transport the salt 400 miles south to Timbuktu, where a 132-pound slab of the highest quality sells for about \$16. Caravans return with supplies and fresh laborers—mostly men and boys who owe city merchants money. Wrapped in rags, a miner's salt-scarred feet tell of the hard life awaiting those who come to this remote outpost—once a government prison—to work off debts.

**ARMED TOUGHS CALLED
US SPIES AND WAVED
THEIR CELL PHONES IN
FRONT OF MY EYES. THE
SCREENS DISPLAYED
BURNING TOWERS AND
LILLIPUTIAN IMAGES OF
OSAMA BIN LADEN.**



NIGER | A U.S. Special Forces weapons sergeant in Maradi shows Nigerian soldiers how to maintain machine guns. Fearful that terrorism will take root in the lawless expanses of the Sahel, threatening global security and West African oil, the U.S. is training the region's militaries.

Sudanese police had shot out their truck windows. The guards pitched them into our cell at midnight. The Russians had broken curfew.

They were helicopter pilots contracted to AMIS, the beleaguered African Union peace-keeping force in Darfur. One began singing patriotic songs that would last all night, and the other two asked why I was there. I told them. I had crossed into Darfur illegally, through the side door of Chad, like scores of other Western journalists. But I had been caught. I faced a 20-year sentence. I had to repeat “spying” three times until they understood.

“Sudan”—spat the small one—“is fakit.” He wore a mullet hairdo and yellow Beatle boots that curled at the tips like elf shoes. Eventually they would all be deported.

Another prisoner had meanwhile escaped in the night—a Darfuri gunrunner—leaving a cupful of his blood splashed on the jail yard wall. He’d maimed himself on the concertina wire. As a result, Idriss, Daoud, and I spent the next two days locked down with 16 other prisoners inside a 15-by-15-foot cell. We hunkered against each other in fetal positions like eggs incubating in a carton. Pickpockets, con men, goat rustlers, two street kids, and a lunatic took turns peeing out the barred door.

This was at the civilian police station, our second place of internment in El Fasher.

The cell’s interior walls were polished black with human grease from the backs of sitting men. Above this wainscoting of grime rose thousands of scrawled names. And some of them were ours.

TIMBUKTU, MALI

In Mali I took a ferry up the Niger River to see the Sahel’s most fabled backwater.

Timbuktu started as a nomads’ watering hole, grew by the 16th century into the Oxford of the Islamic world (25,000 scholars once resided there), and has faded back into a geographic coma. Its sand alleys were like solar ovens. Goats jaywalked on the main street, and dehydrated tourists sent letters postmarked from a town synonymous with the uttermost

end of the Earth. I ducked into the shade of the Imam Ben Essayouti library for a glimpse of a golden age.

Banzoumana Traore was a Malian albino with hazel eyes and a loose cotton suit ablaze with blue and yellow polka dots. I looked again and saw that the dots were antimalaria capsules. Traore was the archivist at the library, which housed a remnant of Timbuktu's priceless trove of medieval manuscripts. With money from South Africa, the U.S., Arab countries, and Europe, small private libraries like this one were popping up all over Timbuktu. They held the Sahel's most astonishing intellectual legacy: tens of thousands of hand-lettered manuscripts, some stored in caves and household cupboards since the city's fall to the Moroccans in 1591. There was love poetry composed in Moorish Spain. There were tracts on Islamic jurisprudence and centuries-old essays on, among other subjects, astronomy, optics, medicine, ethics, and botany. Gazing on these fragile treasures, it was hard not to lament the dearth of book learning in the Arabic-speaking world. A recent UN study found that only 10,000 books have been translated into Arabic over the past 1,200 years—barely equivalent to the number of books Spain translates every year.

Traore's bright pink index finger slid across inks concocted from lampblack. He read aloud of a slave girl in ninth-century Baghdad who shamed the caliph's advisers in a contest of wits (a lesson on women's worth), of a discourse on the Islamic propriety of smoking tobacco (the 223-year-old conclusion was positive), and of an antique memory aid for learning algebra (by matching certain tones to numbers, students could sing out equations).

Timbuktu had been ruled by the kings of Mali and Songhai, by the Moroccans and the colonial French. "Local families guarded the manuscripts through it all," a proud Traore said.

When I arrived, yet another empire was eyeing desolate Timbuktu.

U.S. Special Forces bucked through town in dusty Humvees. Having learned a lesson from Afghanistan—ignorance isn't bliss, and

ruinscapes of poverty, violence, and neglect incubate a murderous rage—Washington was taking a renewed interest in Muslim black Africa. The Pentagon was spending a hundred million dollars a year to train impoverished Sahelian armies in antiterror tactics. A brand-new Africa command center, AFRICOM, would come on line in October 2008, though few African countries wished to host it.

This murky front in the global war on terrorism was yet another invisible line in the Sahel.

It zigzagged across the dunes north of Timbuktu where Green Berets taught Malian soldiers how to ambush Algeria-based jihadists. The Malians were underfed, hyper-courteous, and lacked even the most basic equipment. Some were deaf. Others needed eyeglasses. "They shoot into the sand," drawled a U.S. master sergeant. The world's elite soldiers swooped down on outlying villages like well-toned aid workers, vaccinating babies, filling cavities, and deworming bony nomad cattle. But the most effective hearts-and-minds operation I saw was illicit.

His name was David. His shaved head was burned puce by the sun, his eyes glittered with resolve, and he was a 16-year U.S. Army veteran. He had been deployed to Africa before and wished to convert to Islam, which shows that there is no occupation without counter-occupation. He slipped out of the Special Forces compound at 9 p.m. and drove to the mud-brick palace of Timbuktu's imam. "My gun—I forgot about my gun," he said, realizing he couldn't very well take his pistol to a conversion ceremony. He stashed the weapon under the SUV seat.

The imam was round and jolly and sat cross-legged under a whirring ceiling fan. A television muttered the latest soccer score between Lyon and Real Madrid. The imam instructed David to repeat the *shahadah* three times and lectured him at length on the five pillars of faith, in both Songhai and French.

"I missed some of that," David said.

A half dozen Malian youths took pictures with their cell phones. They were trembling

with excitement. A modern centurion embracing Allah in exotic Timbuktu was a once-in-a-lifetime sight. It made almost anything seem possible. David would later be reprimanded for violating security procedures. But for a few electric minutes amid the tan dunes of Africa, the shadows of Abu Ghraib receded.

"Fin du cérémonie!" declared the imam, clapping his hands. He added for David's sake, "Mission accomplished!" I liked the imam immensely. He was dying to catch the end of the soccer match.

DARFUR—JUDICIARY PRISON

Thursdays were judgment day in El Fasher.

At our third jail, a concrete cellblock outside the local courthouse, Sudanese magistrates in pale blue leisure suits rendered their verdicts according to *hudud*, the Islamic punitive code, and police meted out sentences on the spot with an oxhide whip. I had never seen anyone flogged before. They forced us to watch.

The whip landed with a muffled pop on the backs, buttocks, and legs of prisoners. It was astonishing: How could human beings sweat so much—so fast? After ten blows the prisoners were wet as swimmers. At twenty, the courtyard wall behind the whipping post was spattered with their sweat. The men's muscles spasmed. Their torsos writhed like trees in a gale. But their grit beggared belief. One middle-aged convict, a Darfuri with the respectable, middle-class look of a schoolteacher, took a hundred lashes without crying out. When it was done, he walked with great purpose across the yard, as if on some errand, and toppled facedown in the dust. He was an adulterer.

The chief whip man was Corporal Salah.

He was built square as a butcher's block, and at age 30, his hair was leached of color. Near the end of our imprisonment, on the days when I was feeling bright, I accepted his challenges to play chess. He almost always won. He was a student of the aggressive moves of Bobby Fischer. When he spoke, it was usually in the immature certainties of jihad—"once the world converts to Islam"—but his frequent sighs told

a story of repressed ambition. At night he pored over textbooks on microbiology. He dreamed of laying his big, blunt-fingered hands on the brows of patients in hospital wards. He saw himself clad in the snowy whites of a doctor, not the coarse fatigues of a cop.

Will you believe me when I tell you that there was gentleness in Corporal Salah's heart? That he spoke to his victims tenderly, urging them not to be afraid, even as he scourged the hide on their backs?

By this time our whereabouts had become known. An American Air Force lieutenant colonel and a Marine major brought us Cheez Whiz and every other thing, and an American diplomat brought me Faulkner. Eventually Bill Richardson, governor of my home state of New Mexico, intervened. Daoud and Idriss returned to Chad, to the high wire of the Sahel. I tumbled 20 hours across the Earth in the governor's borrowed jet.

I was doing laundry two months later when the telephone rang. It took me a moment to connect the wiry voice of the caller to certain muscular hands—the fingers clamped on men's shoulders, guiding them firmly to a wall flecked with sweat.

"Hello my friend," Corporal Salah bellowed.

He was shouting over a poor connection. He was in Khartoum, he said, where he'd been transferred, unhappily, to a bigger prison. He asked after my health. But what he really wanted to talk about was the U.S. visa lottery.

SAINT-LOUIS, SENEGAL

The last line in the Sahel was the Atlantic.

The Senegalese capital of Dakar had the fevered feel of an embarkation point—a maritime city of pushy touts, whores for every pocketbook, and scraps of cardboard flattened on sidewalks where visa hunters camped in lines outside European embassies. A reverse trickle of European youngsters, tattooed, puffing cigarettes, self-conscious in their skins, strolled the waterfront. They rode ferries to Île de Gorée, to see the famous "doorway of no return" for slaves bound for the Americas

and Europe. (In truth, few of the estimated 10 to 28 million Africans sold into bondage in the New World ever passed that way.) Senegalese papers told lurid tales of a new exodus: African migrants dying en masse while trying to reach the Canary Islands, an outpost of Europe, in motorized canoes.

For me the Sahel ended at the door of Didier, the captain of one of these boats. I met him in Saint-Louis.

He lived on the beach in a shack above the high-tide mark. He agreed reluctantly to talk. What he was doing was illegal. He had already steered two shiploads of Senegalese, Malians, Guineans, Nigerians, and Burkinabes to the Canaries. All had hocked their bicycles, their wives' treadle sewing machines, their parents' barren farms, their slum shacks—everything they owned to make the \$900 passage to a Sahelian's version of El Dorado: washing dishes in Valencia or hustling leatherware in the piazzas of Rome. Twelve paying customers had died on him. They had gone out of their heads, Didier explained. They guzzled seawater on the five-day, 800-nautical-mile journey through the Atlantic's swells.

"We read the Koran over them and threw them over," he said. "Otherwise they start to stink."

Didier was leaving that evening with another canoe. He would earn a small fortune, a thousand dollars (a good year's wages) in a week. He was beautifully muscled. Yet despite his virile swagger in brand-new jeans and red T-shirt, his glances collapsed inward with fear. He was a man poised on a gangplank. Ambulances were wailing that entire afternoon in Saint-Louis. An emigrant canoe had foundered offshore. Bodies washed up with all the skin abraded from their arms where they had clung to the doomed boat's gunwales. More than a hundred people were missing.

Tens of thousands attempt this passage every year. Hundreds die. The Europeans were sending naval vessels to try to stop them.

What was going on here could just as well be called the mass evacuation of Africa as much

**THE SAHEL IS A BULLET'S
TRAJECTORY. IT IS THE
TRACK OF RAINS THAT
NEVER TOUCH THE SAND.
IT IS A CALL TO PRAYER
AND A CALL FOR BLOOD,
AND FOR ME A DESERT
ROAD WITHOUT END.**

as "illegal migration." It was a desperate flight from a way we'll never be. An underpaid schoolteacher in North America or Europe earns not ten times, not twenty times, but a hundred times more than millions of Sahelians. To think such ravaging disparity will somehow never touch you is foolish. In the teeming fishermen's quarter of Saint-Louis, among the shanties where battered TVs disgorged idiotic French reality shows, and in the sand alleyways speckled with goat droppings, there was talk of bigger canoes, of more barrels of diesel fuel crammed into holds—reenacting the old slave crossing to the Caribbean, to America.

I watched Didier leave at sunset.

I last saw him standing stiffly at the tiller of his boat, wearing a red slicker, nosing out of the harbor amid a screen of other fishing smacks. He did not acknowledge my wave. A little girl did cartwheels on the beach among piles of human waste. Impossibly clean white birds pecked at things. Didier's canoe diminished into a darkening sea that seem sketched in charcoal. I was secretly with them. I saw myself huddled in that plank boat. But even if we all survived, I wasn't sure we would ever truly escape the Sahel.

➤ **Dividing Line** Journey into the harsh and often volatile Sahel with photographer Pascal Maitre and writer Paul Salopek at ngm.com.



CHAD | A sudden downpour drenches women near Abéché during the rainy season. Changing climate has already brought the Sahel not only drier weather but also rains that fall too heavily, too early, or too late: In September 2007 floods inundated the normally parched region. As they have for centuries, the Sahel's people are finding ways to adapt in a land so uncompromising that failure means death. □



BIOMIMETICS ■

design by nature

What has fins like a whale, skin like a lizard, and eyes like a moth? The future of engineering.



Behind the squared-off contours of the boxfish lies a lesson in sleek design. Low drag helps the fish swim up to six body lengths per second, stabilized by the keel-like edges of its carapace.



The boxfish's surprisingly streamlined form inspired Mercedes-Benz's bionic concept car. Flowing vapors during wind-tunnel tests in a Stuttgart facility show off the car's aerodynamics, which helps boost its gas mileage to as high as 70 miles per gallon.





BY TOM MUELLER

PHOTOGRAPHS BY ROBERT CLARK

One cloudless midsummer day in February, Andrew Parker, an evolutionary biologist, knelt in the baking red sand of the Australian outback just south of Alice Springs and eased the right hind leg of a thorny devil into a dish of water. The maneuver was not as risky as it sounds: Though covered with sharp spines, the lizard stood only about an inch high at the shoulder, and it looked up at Parker apprehensively, like a baby dinosaur that had lost its mother. It seemed too cute for its harsh surroundings, home to an alarmingly high percentage of the world's most venomous snakes, including the inland taipan, which can kill a hundred people with an ounce of its venom, and the desert death adder, whose name pretty well says it all. Fierce too is the landscape itself,

Sipping through a foot, the thorny devil lizard of the arid Australian desert demonstrates its ability to wick water to its mouth via channels between its scales. Scientists hope to mimic the mechanism to develop water-capture technologies for dry regions.



where the wind hissing through the mulga trees feels like a blow dryer on max, and the sun seems three times its size in temperate climes. Constant reminders that here, in the driest part of the world's driest inhabited continent, you'd better have a good plan for where your next drink is coming from.

This the thorny devil knows, with an elegance and certainty that fascinated Parker beyond all thought of snakebite or sunstroke. "Look, look!" he exclaimed. "Its back is completely drenched!" Sure enough, after 30 seconds, water from the dish had wicked up the lizard's leg and was glistening all over its prickly hide. In a few seconds more the water reached its mouth, and the lizard began to smack its jaws with evident satisfaction. It was, in essence, drinking through its foot. Given more time, the thorny devil can perform this same conjuring trick on a patch of damp sand—a vital competitive advantage in the desert. Parker had come here to discover precisely how it does this, not from purely biological interest, but with a concrete purpose in mind: to make a thorny-devil-inspired device that will help people collect lifesaving water in the desert.

A slender English academic with wavy, honey-blond hair beneath a wide-brimmed sun hat, Parker busied himself with eyedroppers, misters, and various colored powders, the better to understand the thorny devil's water-collecting alchemy. Now and then he made soft, bell-like, English-academic sounds of surprise and delight. "The water's spreading out incredibly fast!" he said, as drops from his eyedropper fell onto the lizard's back and vanished, like magic. "Its skin is far more hydrophobic than I thought. There may well be hidden capillaries, channeling the water into the mouth." After completing his last experiment, we gathered up his equipment and walked back to our Land Cruiser. The lizard watched us leave with a faint look of bereavement. "Seeing the devil in its natural environment was crucial to understanding the nature of its adaptations—the texture of the sand, the amount of shade, the quality of the light," Parker said as we drove back to camp. "We've done the macro work. Now I'm

ready to look at the microstructure of its skin."

A research fellow at the Natural History Museum in London and at the University of Sydney, Parker is a leading proponent of biomimetics—applying designs from nature to solve problems in engineering, materials science, medicine, and other fields. He has investigated iridescence in butterflies and beetles and antireflective coatings in moth eyes—studies that have led to brighter screens for cellular phones and an anticounterfeiting technique so secret he can't say which company is behind it. He is working with Procter & Gamble and Yves Saint Laurent to make cosmetics that mimic the natural sheen of diatoms, and with the British Ministry of Defence to emulate their water-repellent properties. He even draws inspiration from nature's past: On the eye of a 45-million-year-old fly trapped in amber he saw in a museum in Warsaw, Poland, he noticed microscopic corrugations that reduced light reflection. They are now being built into solar panels.

Parker's work is only a small part of an increasingly vigorous, global biomimetics movement. Engineers in Bath, England, and West Chester, Pennsylvania, are pondering the bumps on the leading edges of humpback whale flukes to learn how to make airplane wings for more agile flight. In Berlin, Germany, the finger-like primary feathers of raptors are inspiring engineers to develop wings that change shape aloft to reduce drag and increase fuel efficiency. Architects in Zimbabwe are studying how termites regulate temperature, humidity, and airflow in their mounds in order to build more comfortable buildings, while Japanese medical researchers are reducing the pain of an injection by using hypodermic needles edged with tiny serrations, like those on a mosquito's proboscis, minimizing nerve stimulation.

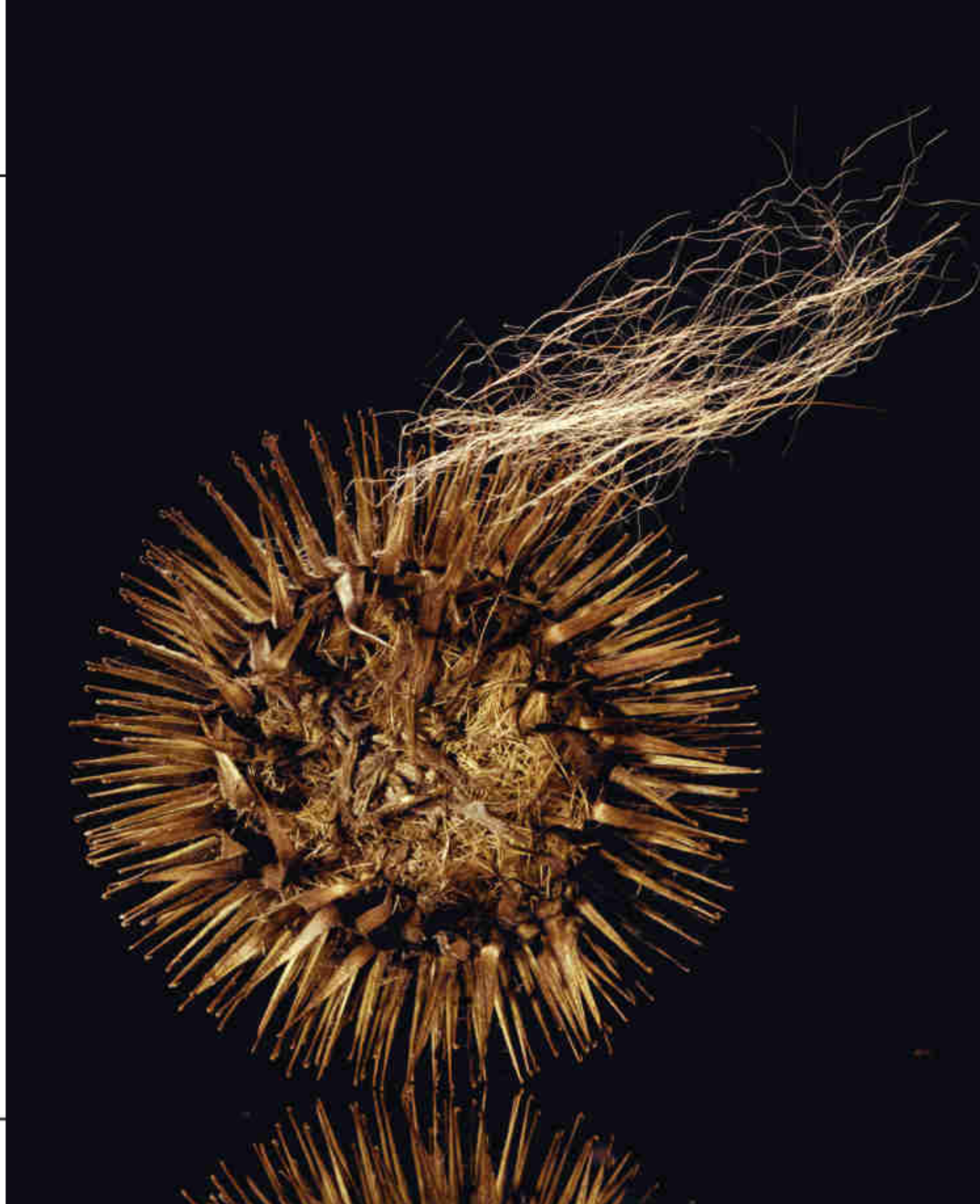
"Biomimetics brings in a whole different set of tools and ideas you wouldn't otherwise have," says materials scientist Michael Rubner of MIT, where biomimetics has entered the curriculum. "It's now built into our group culture."

Shortly after our trip to the Australian desert, I met up with Andrew Parker again, in London, to watch the next phase of his research into the thorny devil. Walking from the Natural History Museum's entrance to his laboratory on the sixth floor, we traversed warehouse-size halls

Tom Mueller writes for the New Yorker, Atlantic, and other publications. Robert Clark photographed the October 2007 cover story on biofuels.

cocklebur

Examining burs plucked from his pants and dog's coat after a hike in 1948, Swiss engineer George de Mestral found their spines were tipped with tiny hooks—sparking his invention of Velcro. He was disappointed that fashion designers didn't rush to adopt his product—"likely because of that ripping sound," says his cousin Etienne Delessert. But Velcro found loftier applications, says Delessert, "in the first artificial heart surgery and on trips into space."



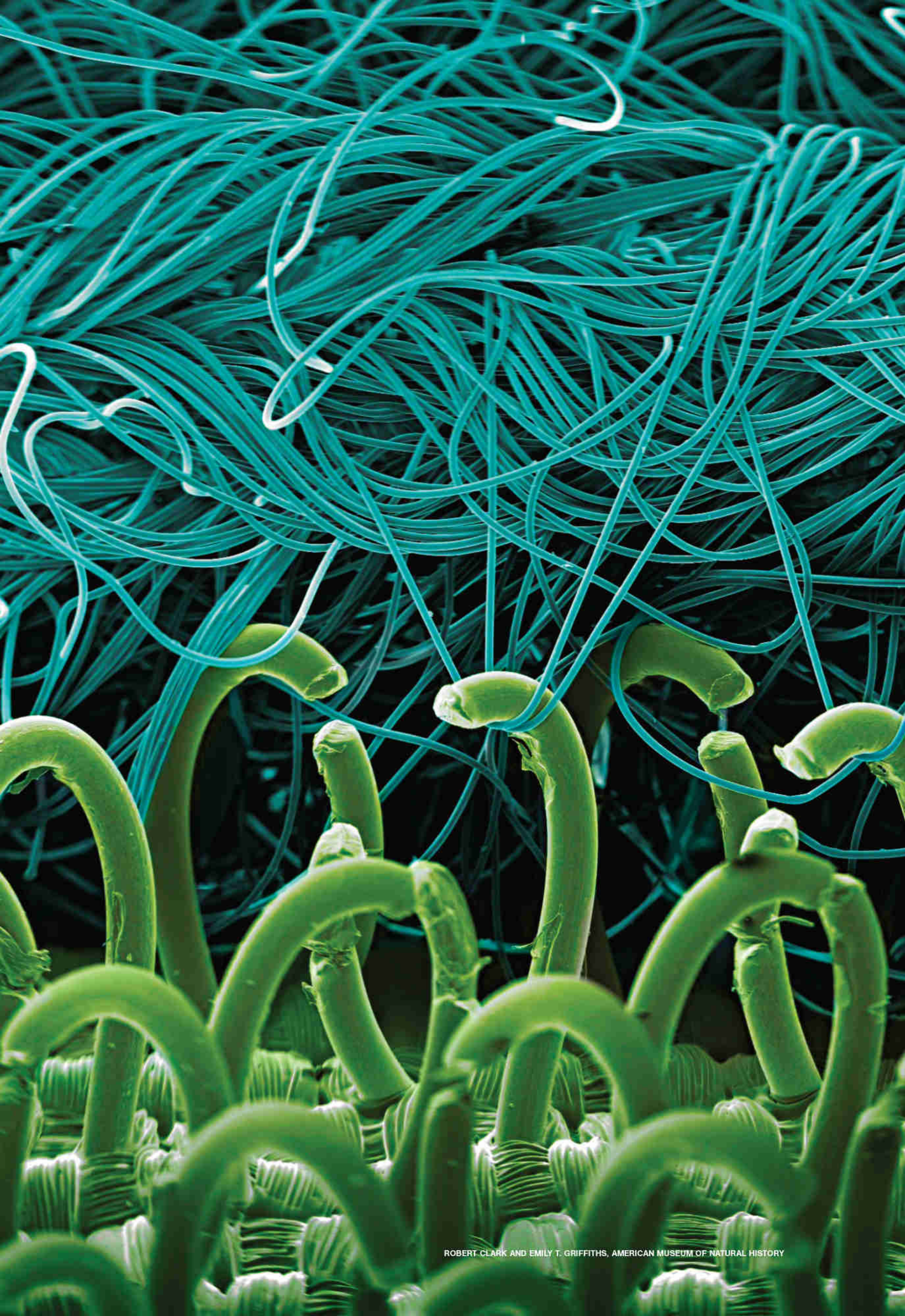
filled with preserved organisms of the most exuberant variety. In one room were waist-high alcohol jars of grimacing sea otters, pythons, spiny echidnas, and wallabies, and one 65-foot-long case containing a giant squid. Other rooms held displays of gaudy hummingbirds, over-the-top toucans and majestic bowerbirds, and shelf after shelf filled with beetles as bright as gemstones: emerald-green scarabs, sapphire-blue *Cyphogastras*, and opalescent weevils.

To Parker this was not a mere collection of specimens, but "a treasure-trove of brilliant design." Every species, even those that have gone extinct, is a success story, optimized by millions of years of natural selection. Why not learn from what evolution has wrought? As we walked, Parker explained how the metallic sheen and dazzling colors of tropical birds and beetles derive not from pigments, but from optical features: neatly spaced microstructures that reflect specific wavelengths of light. Such structural color, fade-proof and more brilliant than pigment, is of great interest to people who manufacture paint, cosmetics, and those little holograms on credit cards. Toucan bills are a model of lightweight strength (they can crack nuts, yet are light enough not to seriously

impede the bird's flight), while hedgehog spines and porcupine quills are marvels of structural economy and resilience. Spider silk is five times stronger by weight and vastly more ductile than high-grade steel. Insects offer an embarrassment of design riches. Glowworms produce a cool light with almost zero energy loss (a normal incandescent bulb wastes 98 percent of its energy as heat), and bombardier beetles have a high-efficiency combustion chamber in their posterior that shoots boiling-hot chemicals at would-be predators. The *Melanophila* beetle, which lays its eggs in freshly burned wood, has evolved a structure that can detect the precise infrared radiation produced by a forest fire, allowing it to sense a blaze a hundred kilometers away. This talent is currently being explored by the United States Air Force.

"I could look through here and find 50 biomimetics projects in half an hour," Parker said. "I try not to walk here in the evening, because I end up getting carried away and working until midnight."

In one such late-night creative burst eight years ago, Parker decided to investigate the water-gathering skills of a desert beetle by building an enormous sand dune in his laboratory. This





With a hook-and-loop construction that grips instantly but lets go with a tug, Velcro (electron micrograph, left) is now as ubiquitous as the zipper. NASA was an early user, sending Velcro to the moon on space boots and suits—including Apollo astronaut John Young's glove in 1972 (above)—on tabs to latch down loose items in zero gravity, and inside helmets as nose scratchers.



tenebrionid beetle flourishes in the Namib Desert in southwestern Africa, one of the world's hottest, driest environments. The beetle drinks by harvesting morning fogs, facing into the wind and hoisting its behind, where hydrophilic bumps capture the fog and cause it to coalesce into larger droplets, which then roll down the waxy, hydrophobic troughs between the bumps, reaching the beetle's mouth. Parker imported several dozen beetles from Namibia, which promptly scampered all over the lab when he opened the box, but eventually settled contentedly on the dune. There, using a hair dryer and various misters and spray bottles, Parker simulated the conditions in the Namib Desert well enough to understand the beetle's mechanism. He then replicated it on a microscope slide, using tiny glass beads for the bumps and wax for the troughs.

For all nature's sophistication, many of its clever devices are made from simple materials like keratin, calcium carbonate, and silica, which nature manipulates into structures of fantastic complexity, strength, and toughness. The abalone, for example, makes its shell out of calcium carbonate, the same stuff as soft chalk. Yet by coaxing this material into walls of staggered, nanoscale bricks through a subtle play of proteins, it creates an armor as tough as Kevlar—

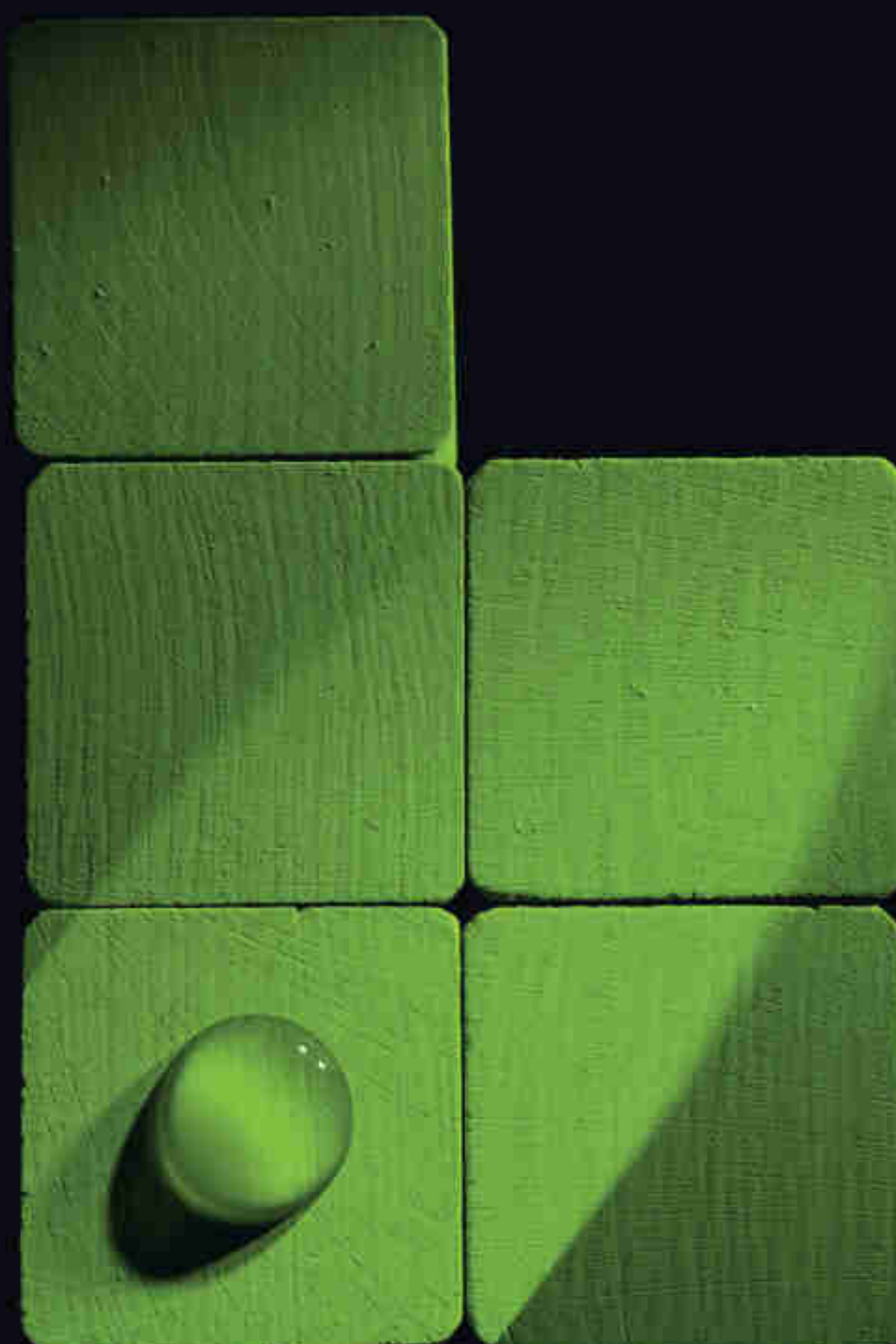
3,000 times harder than chalk. Understanding the microscale and nanoscale structures responsible for a living material's exceptional properties is critical to re-creating it synthetically. So today Andrew Parker had arranged to view the skin of a thorny devil museum specimen under a scanning electron microscope, hoping to find the hidden structures that allow it to absorb and channel water so effectively.

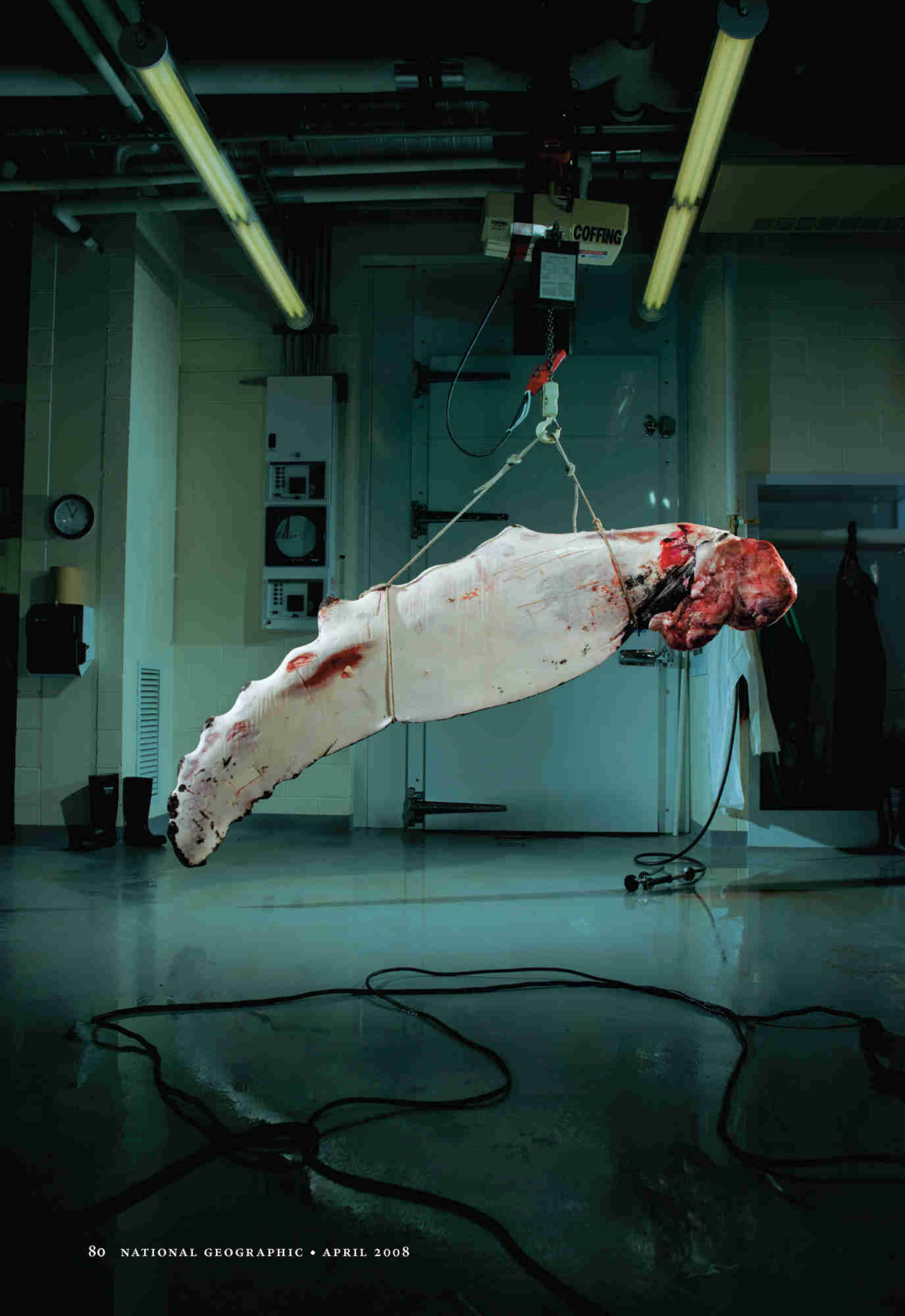
With a microscopist at the helm, we soared over the surface of the thorny devil's skin like a deep-space probe orbiting a distant planet, dipping down now and then at Parker's request to explore some curious feature of the terrain. There seemed to be little of interest in the Matterhorn-like macrostructure of an individual thorn, though Parker speculated that it might wick away heat from the lizard's body or perhaps help capture the morning dew. Halfway down the thorn, however, he noticed a series of nodules set in rows, which seemed to grade down to a larger water-collection structure. Finally we dove into a crevasse at the base of the thorn and encountered a honeycomb-like field of indentations, each 25 microns across.

"Ah-ha!" Parker exclaimed, like Sherlock Holmes alighting upon a clue. "This is clearly a superhydrophobic surface for channeling water

lotus leaf

In 1982 botanist Wilhelm Barthlott of the University of Bonn in Germany discovered in the lotus leaf a naturally self-cleaning, water-repellent surface. The secret lies in waxy microstructures and nanostructures that, by their contact angle with water, cause it to bead and roll away like mercury, gathering dirt as it goes. Barthlott patented his discovery, calling it the Lotus Effect. It has found commercial application in products like the biomimetic paint Lotusan (on blocks at right). Infused with microbumps, the paint is reputed to repel water and resist stains for decades.





between the scales.” A subsequent examination of the thorny devil’s skin with an instrument called a micro-CT scanner confirmed his theory, revealing tiny capillaries between the scales evidently designed to guide water toward the lizard’s mouth. “I think we’ve pretty well cracked the thorny devil structure,” he said. “We’re ready to make a prototype.”

Enter the engineers. As the next phase in his quest to create a water-collection device inspired by the lizard, Parker sent his observations and experimental results to Michael Rubner and his MIT colleague Robert Cohen, a chemical engineer with whom he has worked on several biomimetics projects in the past. Rubner and Cohen are neatly groomed gentlemen who speak in clipped phrases and look frequently at their watches. While Parker likes to explain his work via a stroll through a botanic garden or by pulling out drawerfuls of bright beetles in a museum, they are more likely to draw a tidy graph of force over time, or flip through a PowerPoint presentation on their laptop. But a pooling

of biological insight and engineering pragmatism is vital to success in biomimetics, and in the case of Parker, Cohen, and Rubner, it has led to several promising applications inspired by the Namib beetle and other insects. Using a robotic arm that, in a predetermined sequence, dips slides into a series of nanoparticle suspensions and other exotic ingredients, they have assembled materials layer by layer that have the same special properties as the organisms. Soon they hope to apply the method to create a synthetic surface inspired by thorny devil skin.

Though impressed by biological structures, Cohen and Rubner consider nature merely a starting point for innovation. “You don’t have to reproduce a lizard skin to make a water-collection device, or a moth eye to make an antireflective coating,” Cohen says. “The natural structure provides a clue to what is useful in a mechanism. But maybe you can do it better.” Lessons from the thorny devil may enhance the water-collection technology they have developed based on the microstructure of the

whale flipper

Translating whale power into wind power, biomechanist Frank Fish helped design turbine blades with tubercles (nodules) inspired by the flipper of a humpback whale (left, from a deceased animal). The flipper’s scalloped edge helps it generate force in tightly banked turns. The whale-inspired blades are being tested at the Wind Energy Institute of Canada (below) to see if they can make more power at slower speeds than conventional blades, and with less noise.



Namib beetle, which they're working to make into water-harvesting materials, graffiti-proof paints, and self-decontaminating surfaces for kitchens and hospitals. Or the work may take them in entirely new directions. Ultimately they consider a biomimetics project a success only if it has the potential to make a useful tool for people. "Looking at pretty structures in nature is not sufficient," says Cohen. "What I want to know is, Can we actually transform these structures into an embodiment with true utility in the real world?"

Which, of course, is the tricky bit. Potentially one of the most useful embodiments of natural design is the bio-inspired robot, which could be deployed in places where people would be too conspicuous, bored to tears, or killed. But such robots are notoriously difficult to build. Ronald Fearing, a professor of electrical engineering at the University of California, Berkeley, has taken on one of the biggest challenges of all: to create a miniature robotic fly that is swift, small, and maneuverable enough for use in surveillance or search-and-rescue operations.

If a blowfly had buzzed into Fearing's office when we first sat down on a warm March afternoon, the windows flung wide to the garden-like Berkeley campus, I would have swatted it away without a second thought. By the time Fearing finished explaining why he had chosen it as the model for his miniature aircraft, I would have fallen on bended knee in admiration. With wings beating 150 times per second, it hovers, soars, and dives with uncanny agility. From straight-line flight it can turn 90 degrees in under 50 milliseconds—a maneuver that would rip the Stealth fighter to shreds.

The key to making his micromechanical flying insect (MFI) work, Fearing said, isn't to attempt to copy the fly, but to isolate the structures crucial to its feats of flying, while keeping a sharp eye out for simpler—and perhaps better—ways to perform its highly complex operations. "The fly's wing is driven by 20 muscles, some of which only fire every fifth wing beat, and all you can do is wonder, What on Earth just happened there?" says Fearing. "Some things are just too mysterious and complicated to be able to replicate."

After CalTech neurobiologist Michael Dickinson used foot-long plastic wings flapping in two tons of mineral oil to demonstrate how the fly's

U-shaped beat kept it aloft, Fearing whittled the complexity of the wing joint down to something he could manufacture. What he came up with resembles a tiny automobile differential; though lacking the fly's mystical 20-muscle poetry, it can still bang out U-shaped beats at high speed. To drive the wing, he needed piezoelectric actuators, which at high frequencies can generate more power than fly muscle can. Yet when he asked machinists to manufacture a ten-milligram actuator, he got blank stares. "People told me, 'Holy cow! I can do a ten-gram actuator,' which was bigger than our whole fly."

So Fearing made his own, one of which he held up with tweezers for me to see, a gossamer wand some 11 millimeters long and not much thicker than a cat's whisker. Fearing has been forced to manufacture many of the other minute components of his fly in the same way, using a micromachining laser and a rapid prototyping system that allows him to design his minuscule parts in a computer, automatically cut and cure them overnight, and assemble them by hand the next day under a microscope.

With the microlaser he cuts the fly's wings out of a two-micron polyester sheet so delicate that it crumples if you breathe on it and must be reinforced with carbon-fiber spars. The wings on his current model flap at 275 times per second—faster than the insect's own wings—and make the blowfly's signature buzz. "Carbon fiber outperforms fly chitin," he said, with a trace of self-satisfaction. He pointed out a protective plastic box on the lab bench, which contained the fly-bot itself, a delicate, origami-like framework of black carbon-fiber struts and hairlike wires that, not surprisingly, looks nothing like a real fly. A month later it achieved liftoff in a controlled flight on a boom. Fearing expects the fly-bot to hover in two or three years, and eventually to bank and dive with flylike virtuosity.

To find a biomimetic bot already up and running—or at least ambling—one need only cross the bay to Palo Alto. Ever since the fifth century B.C., when Aristotle marveled at how a gecko "can run up and down a tree in any way, even with the head downward," people have wondered how the lizard manages its gravity-defying locomotion. Two years ago Stanford University roboticist Mark Cutkosky set out to solve

this age-old conundrum, with a gecko-inspired climber that he christened Stickybot.

In reality, gecko feet aren't sticky—they're dry and smooth to the touch—and owe their remarkable adhesion to some two billion spatula-tipped filaments per square centimeter on their toe pads, each filament only a hundred nanometers thick. These filaments are so small, in fact, that they interact at the molecular level with the surface on which the gecko walks, tapping into the low-level van der Waals forces generated by molecules' fleeting positive and negative charges, which pull any two adjacent objects together. To make the toe pads for Stickybot, Cutkosky and doctoral student Sangbae Kim, the robot's lead designer, produced a urethane fabric with tiny bristles that end in 30-micrometer points. Though not as flexible or adherent as the gecko itself, they hold the 500-gram robot on a vertical surface.

But adhesion, Cutkosky found, is only part of the gecko's game. In order to move swiftly—and geckos can scamper up a vertical surface at one meter per second—its feet must also unstick

effortlessly and instantly. To understand how the lizard does this, Cutkosky sought the aid of biologists Bob Full, an expert in animal locomotion, and Kellar Autumn, probably the world's foremost authority on gecko adhesion. Through painstaking anatomical studies, force tests on individual gecko hairlets, and slow-motion analysis of lizards running on vertical treadmills, Full and Autumn discovered that gecko adhesion is highly directional: Its toes stick only when dragged downward, and they release when the direction of pull is reversed.

With this in mind, Cutkosky endowed his robot with seven-segmented toes that drag and release just like the lizard's, and a gecko-like stride that snugs it to the wall. He also crafted Stickybot's legs and feet with a process he calls shape deposition manufacturing (SDM), which combines a range of metals, polymers, and fabrics to create the same smooth gradation from stiff to flexible that is present in the lizard's limbs and absent in most man-made materials. SDM also allows him to embed actuators, sensors, and other specialized structures that

sharkskin

An electron micrograph reveals sharkskin's secret to speed: tooth-like scales called dermal denticles. Water "races through the microgrooves without tumbling," says shark researcher George Burgess, reducing friction. "It's like a fast-moving river current versus the gurgling turbulence of a shallow stream." The scales also discourage barnacles and algae from glomming on—an inspiration for synthetic coatings that may soon be applied to Navy ship hulls to reduce such biofouling.





"No shark will mistake me for one of its own," says ten-time Olympic medalist Gary Hall, Jr., training at Florida's Race Club. But sharkskin denticles spurred the design of his Speedo Fastskin, whose texture functions to reduce drag, bumping up speed.



make Stickybot climb better. Then he noticed in a paper on gecko anatomy that the lizard had branching tendons to distribute its weight evenly across the entire surface of its toes. Eureka. “When I saw that, I thought, Wow, that’s great!” He subsequently embedded a branching polyester cloth “tendon” in his robot’s limbs to distribute its load in the same way.

Stickybot now walks up vertical surfaces of glass, plastic, and glazed ceramic tile, though it will be some time before it can keep up with a gecko. For the moment it can walk only on smooth surfaces, at a mere four centimeters per second, a fraction of the speed of its biological role model. The dry adhesive on Stickybot’s toes isn’t self-cleaning like the lizard’s either, so it rapidly clogs with dirt. “There are a lot of things about the gecko that we simply had to ignore,” Cutkosky says. Still, a number of real-world applications are in the offing. The Department of Defense’s Defense Advanced Research Projects Agency (DARPA), which funds the project, has it in mind for surveillance: an automaton that could slink up a building and perch there for hours or days, monitoring the terrain below. Cutkosky hypothesizes a range of civilian uses. “I’m trying to get robots to go places where they’ve never gone before,” he told

me. “I would like to see Stickybot have a real-world function, whether it’s a toy or another application. Sure, it would be great if it eventually has a lifesaving or humanitarian role....”

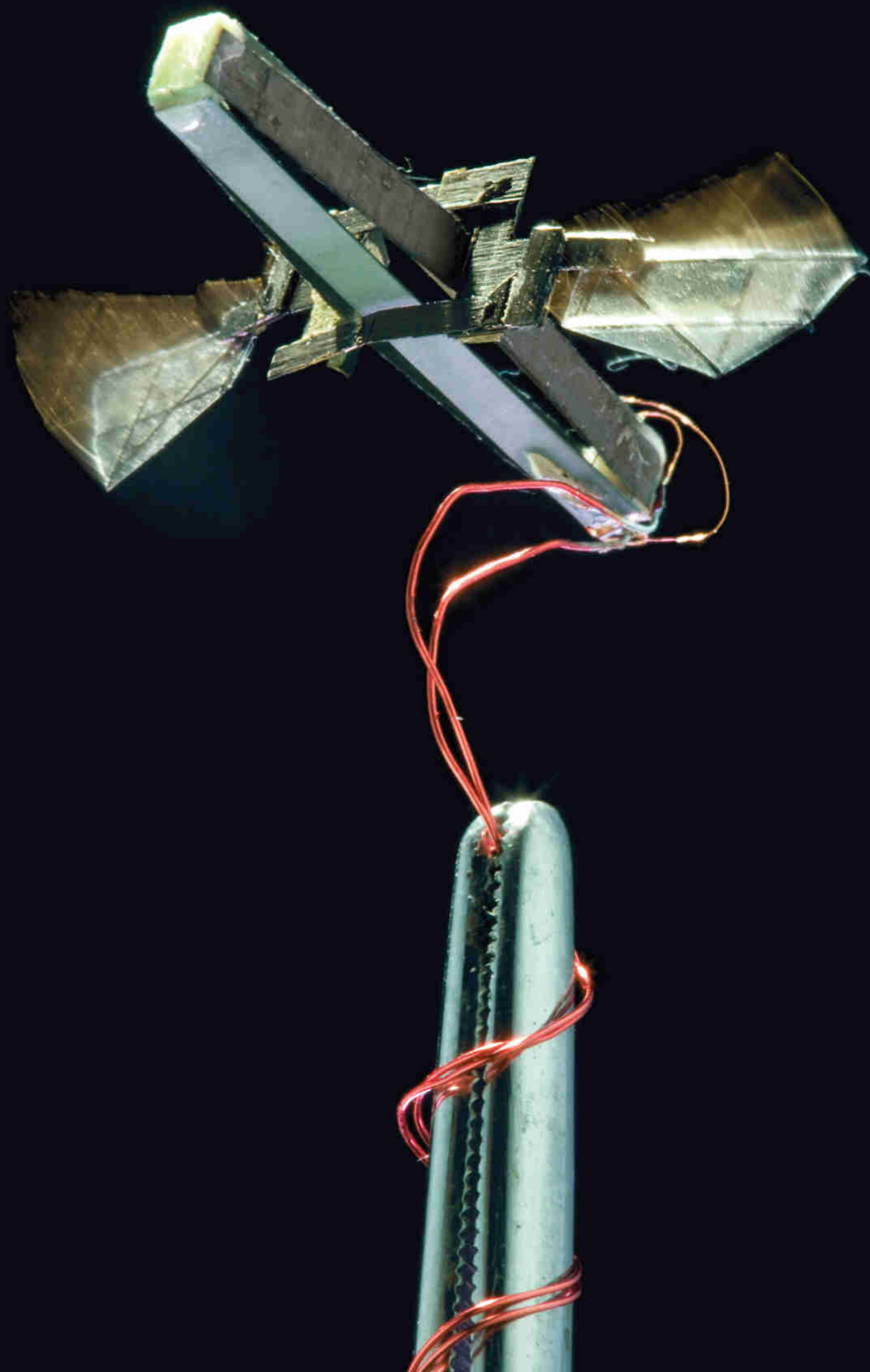
His voice trailed off, in a wistful, almost apologetic tone I had heard undercutting the optimism of several other biomimeticists. For all their differences in background, temperament, and ultimate aims, most practitioners conclude their enthusiastic discourses on their bio-inspired invention with a few halfhearted theories on how it may someday make its way into the real world. Often it sounds like wishful thinking.

For all the power of the biomimetics paradigm, and the brilliant people who practice it, bio-inspiration has led to surprisingly few mass-produced products and arguably only one household word—Velcro, which was invented in 1948 by Swiss chemist George de Mestral, by copying the way cockleburs clung to his dog’s coat. In addition to Cutkosky’s lab, five other high-powered research teams are currently trying to mimic gecko adhesion, and so far none has come close to matching the lizard’s strong, directional, self-cleaning grip. Likewise, scientists have yet to meaningfully re-create the abalone nanostructure that accounts for the strength of its shell, and several well-funded



fly wing

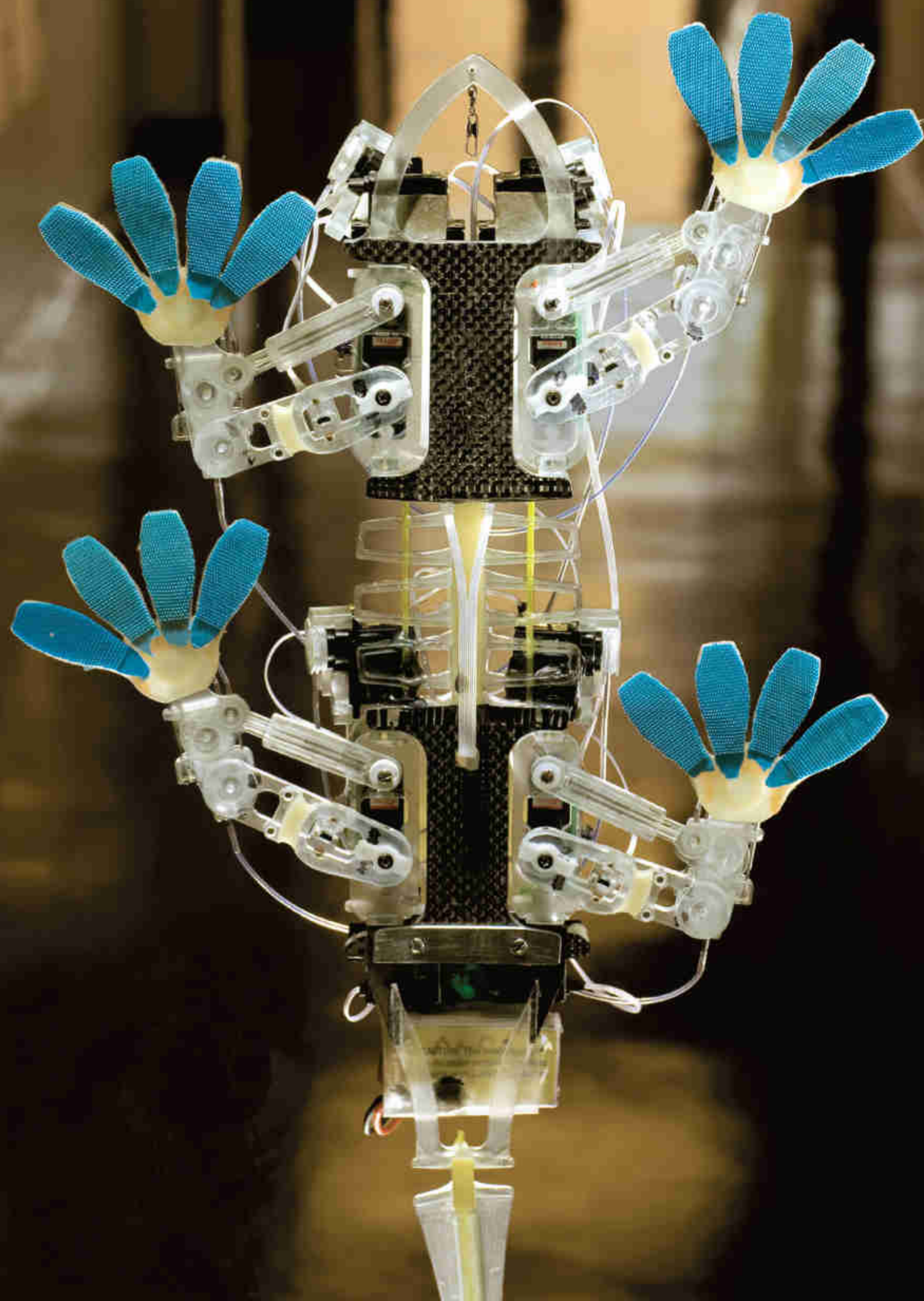
The flutter of the micromechanical flying insect (right) doesn’t yet match the complex U-shaped motion achieved by its living muse, the blowfly. But the robot could soon take flight untethered. Powered by tiny electric actuators along its sides, the bot’s fragile wings beat up to 275 times per second, even faster than the bug’s that inspired it. “A true fly’s wings are remarkable, rotating in every stroke,” says UC Berkeley’s Ron Fearing. “Our challenge is to get a working mechanism in a device one-twentieth the weight of a paper clip.”





gecko foot

A tokay gecko's toes sport spatula-tipped hairs (some 6.5 million of them per toe) that adhere to surfaces at the molecular level, giving the lizard nimble footing even on walls and ceilings. Stickybot (far right), at Stanford University, makes a foray onto similar terrain. Bristled toes grab and let go, and the bot's limbs mimic the gecko's own anatomy. But so far it moves at a relative snail's pace. Designers hope it may one day be used in search-and-rescue applications.



biotech companies have gone bankrupt trying to make artificial spider silk. Why?

Some biomimeticists blame industry, whose short-term expectations about how soon a project should be completed and become profitable clash with the time-consuming nature of biomimetics research. Others lament the difficulty in coordinating joint work among diverse academic and industrial disciplines, which is required to understand natural structures and mimic what they do. But the main reason biomimetics hasn't yet come of age is that from an engineering standpoint, nature is famously, fabulously, wantonly complex. Evolution doesn't "design" a fly's wing or a lizard's foot by working toward a final goal, as an engineer would—it blindly cobbles together myriad random experiments over thousands of generations, resulting in wonderfully inelegant organisms whose goal is to stay alive long enough to produce the next generation and launch the next round of random experiments. To make the abalone's shell so hard, 15 different proteins perform a carefully choreographed dance that several teams of top scientists have yet to comprehend. The power of spider silk lies not just in the cocktail of proteins that it is composed of, but in the mysteries of the creature's spinnerets, where 600 spinning nozzles weave seven different kinds of silk into highly resilient configurations.

The multilayered character of much natural engineering makes it particularly difficult to penetrate and pluck apart. The gecko's feet work so well not just because of their billions of tiny nanohairs, but also because those hairs grow on larger hairs, which in turn grow on toe ridges that are part of bigger toe pads, and so on up to the centimeter scale, creating a seven-part hierarchy that maximizes the lizard's cling to all climbing surfaces. For the present, people cannot hope to reproduce such intricate nanopuzzles. Nature, however, assembles them effortlessly, molecule by molecule, following the recipe for complexity encoded in DNA. As engineer Mark Cutkosky says, "The price that we pay for complexity at small scales is vastly higher than the price nature pays."

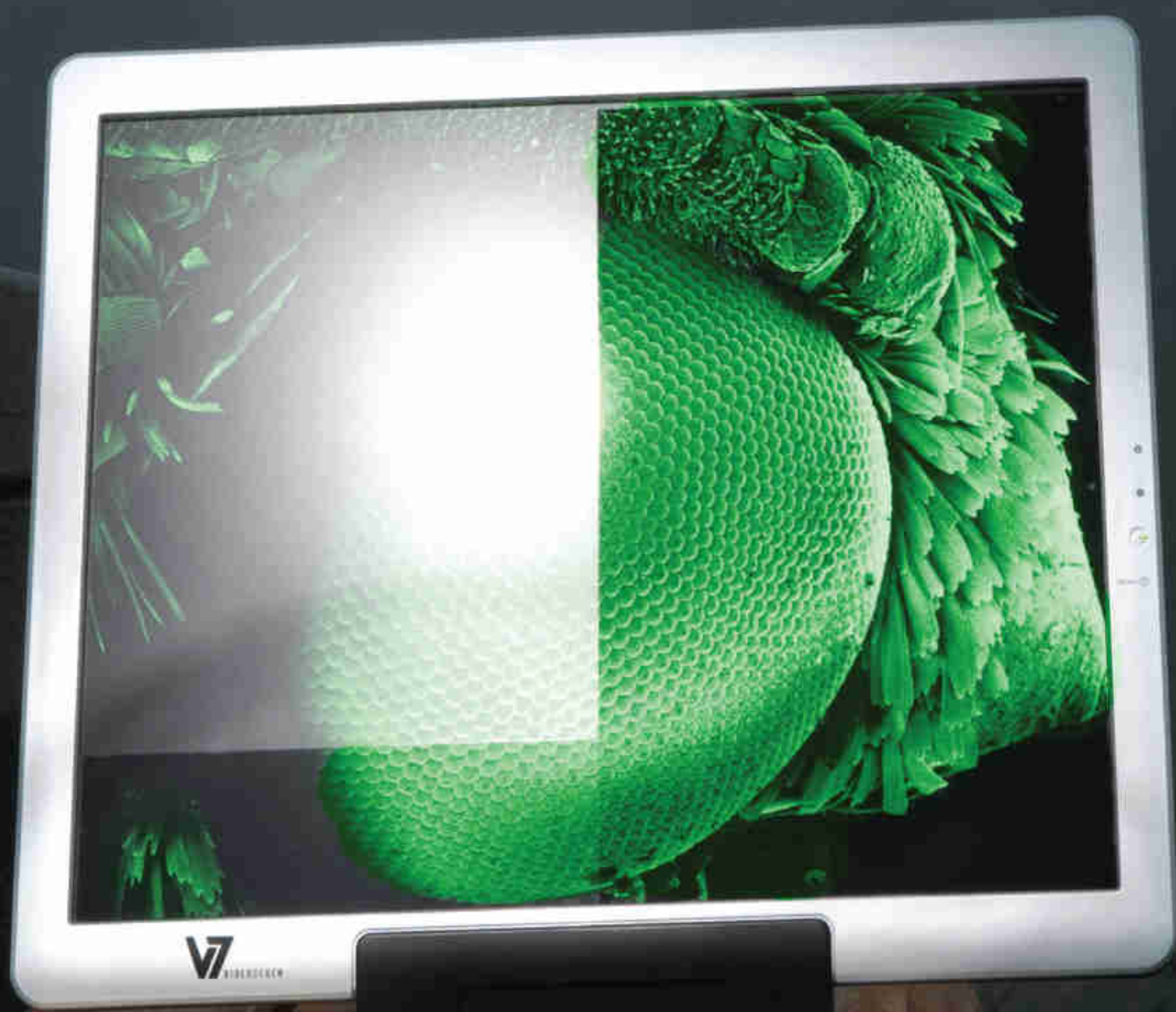
✦ **Designing Images** How does Robert Clark come up with photographs that convey a concept? Learn how he shot this story in a video at ngm.com.

Nonetheless the gap with nature is gradually closing. Researchers are using electron- and atomic-force microscopes, microtomography, and high-speed computers to peer ever deeper into nature's microscale and nanoscale secrets, and a growing array of advanced materials to mimic them more accurately than ever before. And even before biomimetics matures into a commercial industry, it has itself developed into a powerful new tool for understanding life. Berkeley animal locomotion expert Bob Full uses what he learns to build running, climbing, and crawling robots—and they in turn have taught him certain fundamental rules of animal movement. He has discovered, for example, that every land animal, from centipedes to kangaroos to humans, has precisely the same springiness in its legs and generates the same relative energy when it runs. Kellar Autumn, the gecko-adhesion specialist and a former student of Full's, regularly borrows bits of Cutkosky's Stickybot to compare them with the animal's natural structures and to test central assumptions about gecko biology that cannot be learned from the geckos themselves.

"It's no problem to apply a 0.2 Newton preload to a patch of gecko adhesive and drag it in a distal direction at one micron per second," Autumn says. "But try asking a gecko to do the same thing with its foot. It'll probably just bite you." □

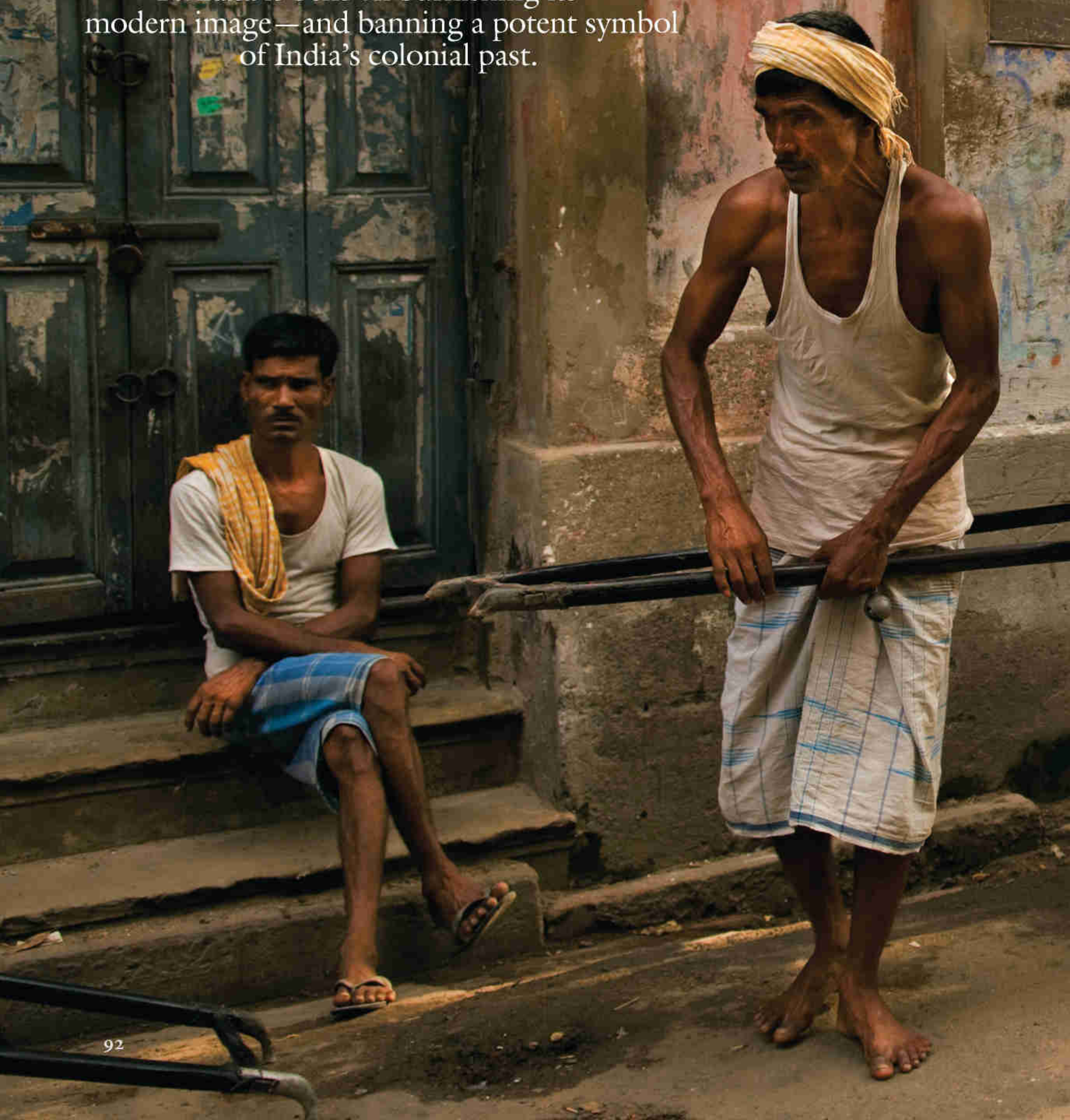
insect eye

In the 1960s scientists studying moth eyes at the nanoscale level discovered that their multifaceted surface (electron micrograph, right) is structured to reduce reflection. Engineers at Holotools in Freiburg, Germany, use lasers to sculpt similar facets on a photosensitive lacquer. Some 16 million "dots" of texture per square millimeter all but eliminate the glare on the right half of a computer monitor. It's an advanced biomimetic technology 40 years—plus eons of evolution—in the making.



Last Days of the Rickshaw

Kolkata is bent on burnishing its modern image—and banning a potent symbol of India's colonial past.



S. K. Bikari regularly pulls a pair of girls to school in the city's fading historic center, yet he rarely sees his own five children back home in the state of Bihar.



by Calvin Trillin
photographs by Ami Vitale

The strategy of drivers in Kolkata—

drivers of private cars and taxis and buses and the enclosed three-wheel scooters used as jitneys and even pedicabs—is simple: Forge ahead while honking. There are no stop signs to speak of. To a visitor, the signs that say, in large block letters, OBEY TRAFFIC RULES come across as a bit of black humor. During a recent stay in Kolkata, the method I devised for crossing major thoroughfares was to wait until I could attach myself to more pedestrians than I figured a taxi was willing to knock down. In the narrow side streets known as the lanes, loud honking is the signal that a taxi or even a small truck is about to round the corner and come barreling down a space not meant for anything wider than a bicycle. But occasionally, during a brief lull in the honking, I'd hear the tinkling of a bell behind me. An American who has watched too many Hallmark Christmas specials might turn around half expecting to see a pair of draft horses pulling a sleigh through snowy woods. But what came into view was a rickshaw. Instead of being pulled by a horse, it was being pulled by a man—usually a skinny, bedraggled, barefoot man who didn't look quite up to the task. Hooked around his finger was a single bell that he shook continuously, producing what is surely the most benign sound to emanate from any vehicle in Kolkata.

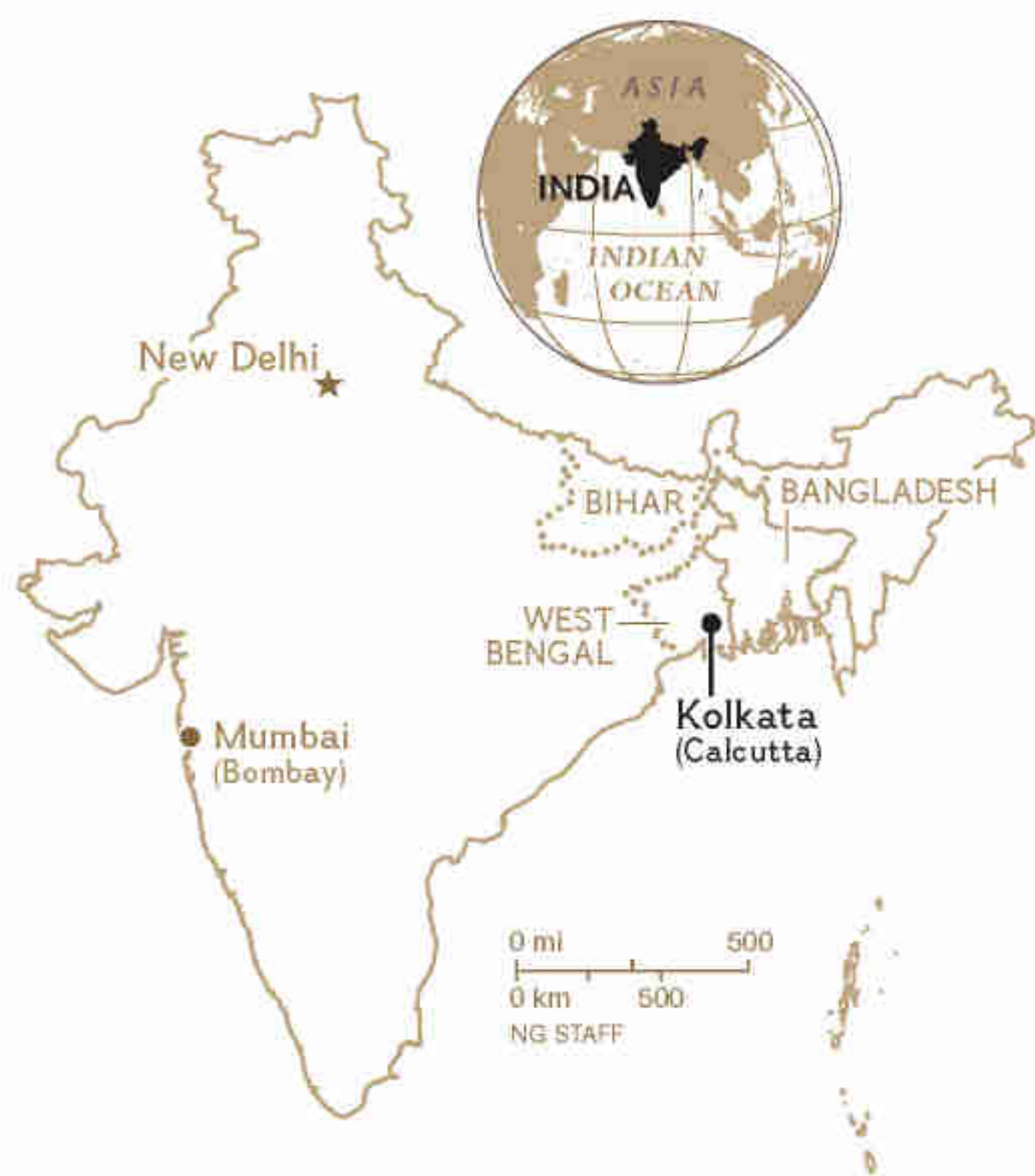
Among the great cities of the world, Kolkata, the capital of West Bengal and the home of nearly 15 million people, is often mentioned as the only one that still has a large fleet of hand-pulled rickshaws. As it happens, that is not a distinction treasured by the governing authorities. Why? It's tempting, of course, to blame Mother Teresa. A politician in Kolkata told me that the city is known for the three *m*'s: Marxism, *mishti*, and Mother Teresa. (West Bengal has had a government dominated by the Communist Party for 30 years. *Mishti* is a sweetened yogurt that Kolkatans love, though they're also partial to a sweet called *rossogolla*.) There is no doubt that the international attention given to Mother Teresa's work among the wretched and the dying firmly linked Kolkata in the Western mind with squalor—no matter how often Kolkatans point out that Mumbai, for example, has more extensive slums, and that no other city in India can match the richness of Kolkata's intellectual and cultural life.

The most loyal booster of Kolkata would acknowledge that the city has had some genuinely trying times in the 60 years since India became independent, starting well before the emergence of Mother Teresa. The partition that accompanied independence meant that, without substantial help from

In the midst of a monsoon rain, Mohammad S. K. Rostam and his fellow rickshaw pullers provide the best transport through flooded streets.







Risking a fine, a puller takes a shortcut by traveling against traffic on a one-way street. With little education or professional training, the men who do this grueling work have few other job prospects. Many come from Bihar (map), one of India's poorest states.





the central government, Kolkata had to absorb several million refugees from what became East Pakistan. There were times in the 1970s and '80s when it seemed Kolkata would never recover from the trauma of those refugees, followed by another wave of refugees who came during the war that turned East Pakistan into Bangladesh. Those were years marked by power outages and labor unrest and the flight of industry and the breathtaking violence unleashed by the Naxalite movement, which began with peasants demanding land redistribution in rural West Bengal and was transformed by college students into urban guerrilla warfare. In 1985 India's own prime minister, then Rajiv Gandhi, called Kolkata "a dying city."

There are still a lot of people sleeping on the streets in Kolkata, but there have been great changes in recent years. After decades of concentrating on its base among the rural poor and disdaining outside investment, the Communist Party of West Bengal has fiercely embraced capitalism and modernity. Although the government's symbols remain what might be expected from a party that still has a politburo—street-name changes have resulted in an American consulate with the address 5/1 Ho Chi Minh Road—the city regularly courts Western delegations looking for investment opportunities. Kolkata now has modern shopping malls and modern overpasses. Walking around the city recently for a week or so, often as the only Westerner in sight, I was approached by precisely two beggars.

Still, the image of any city has a half-life of many years. (So does its name, officially changed in 2001 from Calcutta to Kolkata, which is closer to what the word sounds like in Bengali. Conversing in English, I never heard anyone call the city anything but Calcutta.) To Westerners, the conveyance most identified with Kolkata is not its modern subway—a facility whose spacious stations have art on the walls and cricket matches on television monitors—but the hand-pulled rickshaw. Stories and films celebrate a primitive-looking cart with high wooden wheels, pulled by someone who looks close to needing the succor of Mother Teresa. For years the government has been talking about eliminating hand-pulled rickshaws on what it calls humanitarian grounds—principally on the ground that, as the mayor of Kolkata has often said, it is offensive to see "one man sweating and straining to pull another man." But these days politicians also lament the impact of 6,000 hand-pulled rickshaws on a modern city's traffic and, particularly, on its image. "Westerners try to associate beggars and these rickshaws with the Calcutta landscape, but this is not what Calcutta stands for," the chief minister of West Bengal, Buddhadeb Bhattacharjee, said in a press conference in 2006. "Our city stands for prosperity and development." The chief minister—the equivalent of a state governor—went on to announce that hand-pulled rickshaws soon would be banned from the streets of Kolkata.

Rickshaws are not there to haul around tourists. (Actually, I saw almost no tourists in Kolkata, apart from the young backpackers on

Calvin Trillin is the author of 25 books of journalism, fiction, verse, and autobiography, most recently About Alice. Ami Vitale's photographs have appeared in GEO, Newsweek, Time, Smithsonian, and the New York Times.



A rickshaw stand is also home to Dharmindra Singh (at left) and Bhanu Paswan, who brought their



families with them to live on the street rather than visiting them once a year in Darbhanga, Bihar.

Pullers pay \$2.50 a month for lodging in a dera, which



Taking a break after lunch, rickshaw pullers crowd into their living quarters, called a dera. Though religious tensions often run high in India, Hindus and Muslims share the tight lodging.

Sudder Street, in what used to be a red-light district and is now said to be the single place in the city where the services a rickshaw *wallah* offers may include providing female company to a gentleman for the evening.) It's the people in the lanes who most regularly use rickshaws—not the poor but people who are just a notch above the poor. They are people who tend to travel short distances, through lanes that are sometimes inaccessible to even the most daring taxi driver. An older woman with marketing to do, for instance, can arrive in a rickshaw, have the rickshaw *wallah* wait until she comes back from various stalls to load her purchases, and then be taken home. People in the lanes use rickshaws as a 24-hour ambulance service. Proprietors of cafés or corner stores send rickshaws to collect their supplies. (One morning I saw a rickshaw *wallah* take on a load of live chickens—tied in pairs by the feet so they could be draped over the shafts and the folded back canopy and even the axle. By the time he trotted off, he was carrying about a hundred upside-down chickens.) The rickshaw pullers told me their steadiest customers are school-children. Middle-class families contract with a puller to take a child to

sounds like a good deal until you've visited one.



On a visit from Bihar to celebrate a holiday, Rabson Khatoon and her grandchildren use her son's dera as a living room. It also serves as a garage, repair shop, kitchen, closet, bedroom, and bath.

school and pick him up; the puller essentially becomes a family retainer.

From June to September Kolkata can get torrential rains, and its drainage system doesn't need torrential rain to begin backing up. Residents who favor a touch of hyperbole say that in Kolkata "if a stray cat pees, there's a flood." During my stay it once rained for about 48 hours. Entire neighborhoods couldn't be reached by motorized vehicles, and the newspapers showed pictures of rickshaws being pulled through water that was up to the pullers' waists. When it's raining, the normal customer base for rickshaw wallahs expands greatly, as does the price of a journey. A writer in Kolkata told me, "When it rains, even the governor takes rickshaws."

While I was in Kolkata, a magazine called *India Today* published its annual ranking of Indian states, according to such measurements as prosperity and infrastructure. Among India's 20 largest states, Bihar finished dead last, as it has for four of the past five years. Bihar, a couple hundred miles north of Kolkata, is where the vast majority of rickshaw wallahs come from. Once in Kolkata, they sleep on the street or in their rickshaws or in a *dera*—a combination garage and repair shop and dormitory managed



Live chickens ride on Gopal Shaw's rig from the wholesale New Market to a retail shop. A puller's day



may begin with such early morning deliveries and end after midnight with passengers.

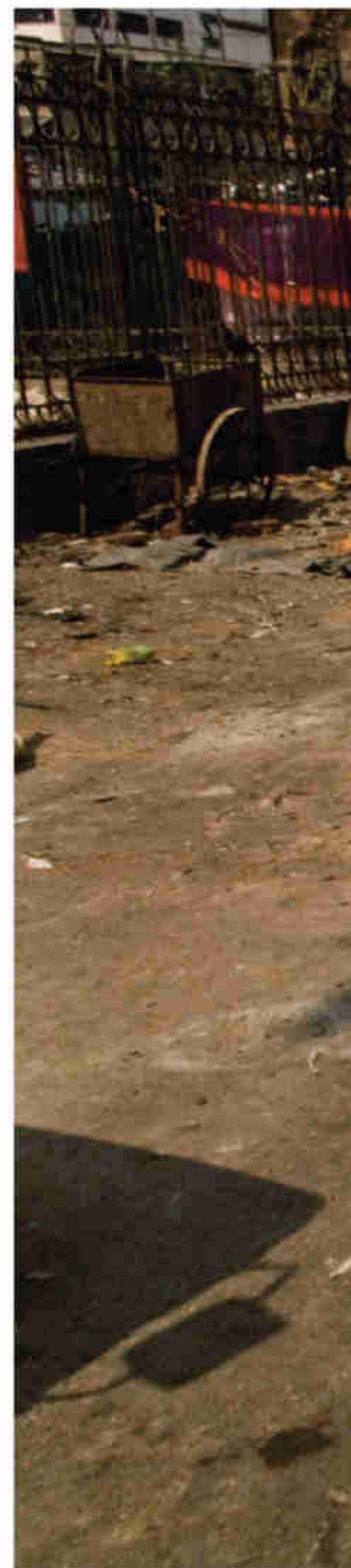
Some people will not ride because they are offended

by someone called a *sardar*. For sleeping privileges in a dera, pullers pay 100 rupees (about \$2.50) a month, which sounds like a pretty good deal until you've visited a dera. They gross between 100 and 150 rupees a day, out of which they have to pay 20 rupees for the use of the rickshaw and an occasional 75 or more for a payoff if a policeman stops them for, say, crossing a street where rickshaws are prohibited. A 2003 study found that rickshaw wallahs are near the bottom of Kolkata occupations in income, doing better than only the ragpickers and the beggars. For someone without land or education, that still beats trying to make a living in Bihar.

There are people in Kolkata, particularly educated and politically aware people, who will not ride in a rickshaw, because they are offended by the idea of being pulled by another human being or because they consider it not the sort of thing people of their station do or because they regard the hand-pulled rickshaw as a relic of colonialism. Ironically, some of those people are not enthusiastic about banning rickshaws. The editor of the editorial pages of Kolkata's *Telegraph*—Rudrangshu Mukherjee, a former academic who still writes history books—told me, for instance, that he sees humanitarian considerations as coming down on the side of keeping hand-pulled rickshaws on the road. "I refuse to be carried by another human being myself," he said, "but I question whether we have the right to take away their livelihood." Rickshaw supporters point out that when it comes to demeaning occupations, rickshaw wallahs are hardly unique in Kolkata.

When I asked one rickshaw wallah if he thought the government's plan to rid the city of rickshaws was based on a genuine interest in his welfare, he smiled, with a quick shake of his head—a gesture I interpreted to mean, "If you are so naive as to ask such a question, I will answer it, but it is not worth wasting words on." Some rickshaw wallahs I met were resigned to the imminent end of their livelihood and pin their hopes on being offered something in its place. As migrant workers, they don't have the political clout enjoyed by, say, Kolkata's sidewalk hawkers, who, after supposedly being scaled back at the beginning of the modernization drive, still clog the sidewalks, selling absolutely everything—or, as I found during the 48 hours of rain, absolutely everything but umbrellas. "The government was the government of the poor people," one sardar told me. "Now they shake hands with the capitalists and try to get rid of poor people."

But others in Kolkata believe that rickshaws will simply be confined more strictly to certain neighborhoods, out of the view of World Bank traffic consultants and California investment delegations—or that they will be allowed to die out naturally as they're supplanted by more modern conveyances. Buddhadeb Bhattacharjee, after all, is not the first high West Bengal official to say that rickshaws would be off the streets of Kolkata in a matter of months. Similar statements have been made as far back as 1976. The ban decreed by Bhattacharjee has been delayed by a court case and by a widely held belief that some retraining or social security settlement ought to be offered to rickshaw drivers. It may also



➤ **Leaving Rickshaws Behind** More of Ami Vitale's photos can be found at ngm.com.

by the idea of being pulled by another human being.



Pounding rough asphalt, often barefoot, earns a puller a meager but honest living. What will he do—and how will his clients get around—if rickshaws are finally forced off the roads?

have been delayed by a quiet reluctance to give up something that has been part of the fabric of the city for more than a century. Kolkata, a resident told me, “has difficulty letting go.” One day a city official handed me a report from the municipal government laying out options for how rickshaw wallahs might be rehabilitated.

“Which option has been chosen?” I asked, noting that the report was dated almost exactly a year before my visit.

“That hasn’t been decided,” he said.

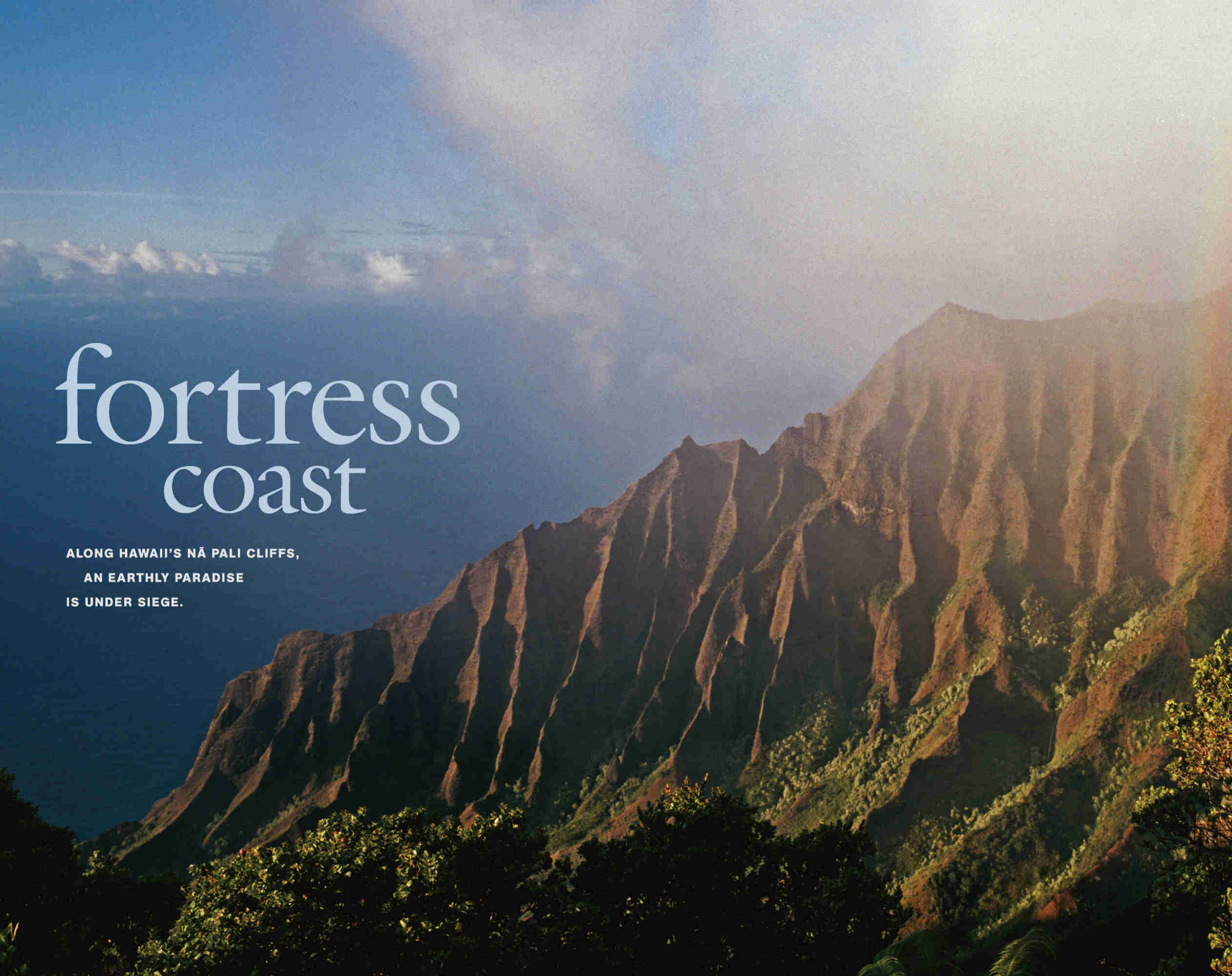
“When will it be decided?”

“That hasn’t been decided,” he said. □



Tumbling 4,000 feet from source to sea cave (left), Waiahuakua stream—"waters of the altar of the gods"—is one of many Nā Pali features venerated by early Hawaiians. Another hallowed spot is Polihale Beach and nearby cliffs (right), the jumping-off spot for spirits bound for the netherworld.



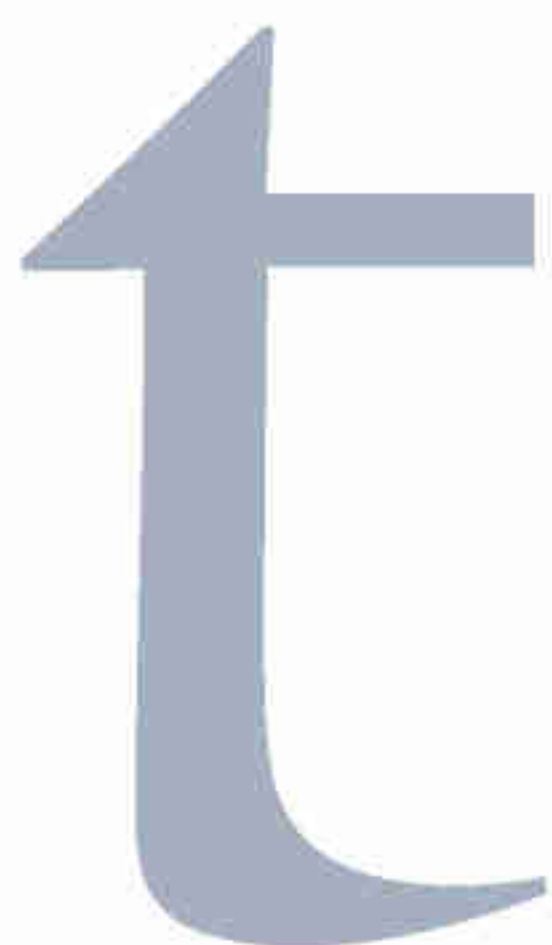


fortress coast

ALONG HAWAII'S NĀ PALI CLIFFS,
AN EARTHLY PARADISE
IS UNDER SIEGE.



Draped in iridescent hues, rugged Nā Pali Coast on Kaua'i provides a rampart against the Pacific—and a pot of tourist gold.



he road to Shangri-la is supposed to be an ephemeral thing, a mystical path to a hidden valley where peace and beauty prevail. But on the Hawaiian island of Kaua'i it's simply Kuhio Highway, a twisty two-lane blacktop that ends in a muddy parking lot on the island's north shore. There, past the sands of Kē'e Beach, the cliffs of Nā Pali rise straight from the green Pacific like giant palisades that keep the modern world at bay.

It's a lovely illusion, of course. Unlike the fabled Shangri-la, Nā Pali is emblazoned on every tourist map of Kaua'i—and this magazine is partly to blame. A single photo in a 1960 article on Hawaii unveiled a lush valley shielded by 3,000-foot cliffs to a generation hungry for just such a place. The caption read: "Napali's towering cliffs wall a Shangri-la valley accessible only by sea.... Junglelike glens tucked amid the ridges offer an unspoiled world for the adventurous."

That image, and many more that followed in print and film, inspired a pilgrimage that continues to this day. Some visitors kayak the 15-mile stretch of fluted cliffs, sea caves, and scalloped beaches during the calm seas of summer; others make the trip in "extreme" rafts, outboard-powered assault craft that can surmount almost any sea. Even more take the one-hour helicopter tour to get the *Jurassic Park* view—Nā Pali starred in that movie, as well as in *King Kong*, *South Pacific*, and many other Hollywood fantasies. The young in heart and leg hike a harrowing 11-mile goat trail to the largest of the valleys, called Kalalau, where they often overstay their five-day camping permits by weeks or even months.

All are latecomers to a geologic drama that has played out over millions of years. The Nā Pali Coast is the scarred shoulder of an ancient shield volcano that once rose more than five miles from seafloor to summit. Like all the Hawaiian islands, Kaua'i was born over a plume

of magma called a hot spot. As tectonic forces moved the island off the hot spot, its volcanic fires cooled and water, Earth's elemental sculptor, took over. Rain—nearly a hundred inches a year in parts of Nā Pali—carved out the deep valleys from above and draped white-plumed waterfalls over the precipices. Giant winter waves exploded against the basalt cliffs as sea level rose and fell, gouging steep, unstable slopes. The result: a series of plunging valleys, fluted walls, and razor-sharp ridges soaring thousands of feet from the Pacific. On big screens and small, Nā Pali has come to represent paradise on Earth.

For the early Hawaiians, it was also home, a place to fish and plant their terraced taro fields. Their presence is palpable in Nu'alolo Kai, one of the westernmost valleys along the coast, now accessible only by boat. Signs of more than six centuries of continuous occupation dot the landscape: stone walls, ceremonial platforms, remnants of houses and canoe shelters, as well as numerous burial sites.

In Hawaiian culture everything in the world contains *mana*, a spiritual power imbued by the gods and the ancestors. The mana at Nu'alolo Kai is so strong even a visitor from halfway across the globe gets goose bumps. "The Hawaiians call the feeling 'chicken skin,'" says Alan Carpenter, an archaeologist with Hawaii's division of state parks, which administers the area. "I get it every time I come here."

For Randy Wichman and Sabra Kauka, this valley also inspires a powerful sense of peace and serenity. The two native Hawaiians are members of Nā Pali Coast 'Ohana, a local non-profit group formed to protect the cultural

Diane Cook and Len Jenshel's first joint project focused on volcanic landscapes. Their latest book explores the spectacle of public aquariums.



Invasive species, such as bamboo, rival native plants in Nā Pali's lush valleys.

sites along the coast. “I have a board member who can’t take Novocain,” Kauka says. “So when he recently had a root canal, he just visualized himself here. I think his dentist was more nervous than he was.”

Carpenter and Wichman take me to one of the platforms beneath the amphitheater of the cliff, and together we try to imagine the celebrations that occurred here centuries earlier. During *‘awa* ceremonies—*‘awa*, or kava, being the favorite ritual drink of Polynesia—high priests performed ritual sacrifices, hula dancers swayed to the beat of drums, and from the highest cliff, called Kamaile, young men hurled burning javelins like comets into the sea. These fireworks were so spectacular even King Kamehameha II made a special trip to view them.

Yet fireworks and celebrations were not enough to sustain these native Hawaiians. Perhaps they were cut down by Western diseases that ravaged the islands during the 1800s. Or maybe their traditional trading system no longer worked in the new money-based economy. No

one knows for sure. But after more than 600 years of continuous habitation, the last permanent residents left the valley in the early 1900s for more populated parts of the island.

According to Carpenter, the parks archaeologist, Nu‘alolo Kai is one of the more important archaeological sites on the islands. A decade of budget cuts, however, has created a maintenance backlog of 125 million dollars in the state’s parks, making it tough to maintain even a picnic shelter and composting toilet at the site. Care of the area falls largely to volunteers and local watermen, with Carpenter and other archaeologists providing expertise and sharing in the sweat. It’s tough work, clearing brush, rebuilding stone structures, and hauling trash. But for Sabra Kauka, it provides a personal connection to the landscape, one she hopes isn’t lost on the many local students she brings here to help with the work.

“In Hawaiian there is a saying, *‘Ma ka hana ka ‘ike*—In the work is the knowledge,” she says. “If you want to learn about this place, you





Razor-sharp ridges tower over the Pacific, inspiring legends of giant sculptors and children of the gods turned to stone. In reality, the basalt pillars are the fraying hem of the shield volcano that created Kaua'i, incised by more than a million years of nearly constant erosion.

have to take care of this place, and then it will reveal itself to you.”

Her words echo in my ears a few days later as I slowly work my way across a crumbling pali (*nā pali* means “the cliffs” in Hawaiian) on the trail to the Kalalau Valley. Sweat falls in steady drops from my hat to the narrow trail, which wends a very fine line between a rock wall and a sheer 800-foot drop to the sparkling sea. Early Western visitors reported seeing Hawaiians running along these trails, sometimes two abreast. Today a parade of “flightseeing” helicopters buzz by like giant gnats.

Despite the difficulty of the trail, I pass several people coming and going, some of the half million visitors from all over the world who flock here each year. The ones I meet include some serious hikers, a few college kids in bathing suits and sandals, and one or two obvious “Kalalau outlaws”—bearded men in their 40s or 50s with ragged clothes and furtive looks. These modern-day hermits live in the remote valley, eluding occasional roundups to evict them.

With abundant water, rich soils, and plenty of papaya, coconut, and java plum trees, Kalalau has provided refuge for many outcasts over the years. In 1893 several Hawaiians with leprosy

AS I WATCH THE SUN MELT INTO THE SEA, A PASSING SHOWER UNCORKS A MAGNIFICENT RAINBOW. HOW COULD HUMANS TRASH SUCH A PARADISE?

moved their families to the valley to keep from being banished to the dreaded leper colony on Molokaʻi. When the deputy sheriff of Waimea came to round up the sick ones, a well-known cowboy and crack shot named Koʻolau refused to go without his wife and son. The standoff lasted into the night, until shots rang out and the deputy fell dead. Hawaii’s new provisional government, fresh from deposing Queen Liliʻuokalani, feared an open revolt and sent the army after the cowboy. But Koʻolau evaded his pursuers in the cracks and crags of the valley, eventually dying there of his disease. “Koʻolau the Leper” became a modern folk hero of Hawaii.

Decades later another group of social outcasts sought peace in the valley—young hippies who spent years living off the land and communing with nature until eventually they were roused



out by the law. At a bend in the trail I meet one hiker of that generation and ask him if he'd been to Kalalau. "I was there in the 1960s," he said with a warm smile. "It was pristine. Everybody ran around naked. But hey, it was the '60s!"

When I finally reach the magical valley with its folded cliffs and sinuous beach, the vibe is more frat party than nudist retreat. Dozens of campers, some apparently long-term, are scattered among the trees behind the beach. A group of college kids have a boombox blaring, and a woman with bright red hair is shaving her legs in the valley's famous waterfall. Bags of garbage, old coolers, and discarded tents are strewn about the campsites and sea caves, waiting for work crews to haul them out by helicopter—the greatest expense for the cash-strapped park.

"The challenge of managing Kalalau is its isolation, which is also its attraction," state parks administrator Dan Quinn told me later. "If we'd get more people carrying out what they carry in, it would be a better experience for everyone."

As I watch the sun melt into the sea, a passing shower uncorks a magnificent rainbow. How could humans trash such an earthly paradise? The fictional Shangri-la, as portrayed in James Hilton's 1933 novel *Lost Horizon*, was inspired

by the Buddhist concept of Shambhala, a mythical place of peace and tranquillity reached by enlightened beings. Maybe we aren't there yet.

On my last day in Kalalau, however, I meet someone who seems well along the way. A young outlaw with a massive backpack bounds down the last stretch of trail as I'm starting the long climb out. He drops his burden at my feet, sprawls on the grass, and tells me his name is Eric. He's planning to stay for two months in a cave up the valley, foraging, meditating, and "getting centered" with the universe. "You go back up that valley and there are rock platforms, taro fields, sacred altars all the way up," he says. "It was a metropolis in there! It's the land of the menehune, the ancient ones. It's primal!"

Eric is bright, articulate, and seems utterly at peace with himself and the world. We chat for a while, and then he picks up his 75-pound pack as if it were full of feathers and lopes down the trail, singing a joyful tune. "Enjoy your journey on planet Earth!" he shouts in parting. And for the rest of the day, I do.

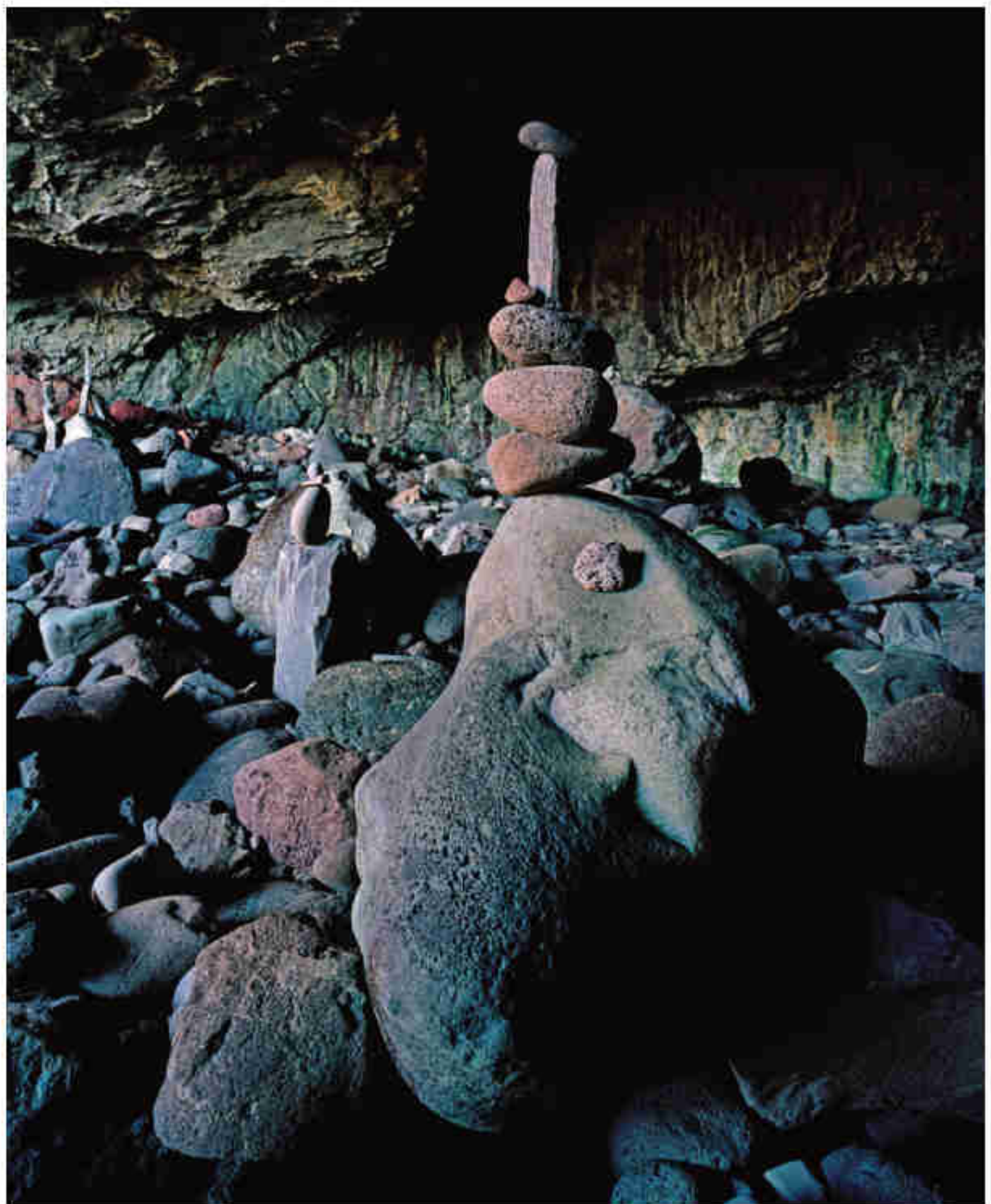
➤ **Pacific Apertures** Explore Nā Pali's magnificent beaches and vistas, and find out where the images were taken in an interactive map at ngm.com.







A banyan tree spreads its roots near a *heiau*, a sacred spot where early Hawaiians once made offerings. Many natural and cultural sites on Nā Pali Coast are threatened by non-native plants and misguided visitors. Some campers dismantle historic stone works to build fire rings, while others leave trash or traces of their visit, like the faux *ahu*, or altars (below) in a Kalalau sea cave.







Sunset bathes the battlements of Kalalau, the largest valley on Nā Pali Coast. The famous fluted walls are the result of varying rates of weathering and erosion. The valley is accessible only by boat, when the seas are calm in summer, or by way of a dizzying 11-mile trail that hugs the cliffs.





Just before setting,
the moon silvers the
waves washing Kalalau
Beach. An old Hawaiian
legend tells of Pele,
goddess of fire, coming
to this coast in search
of a home, but she was
driven away by a
goddess of the sea.
Their contest continues
today, with the sea
winning bit by bit. □

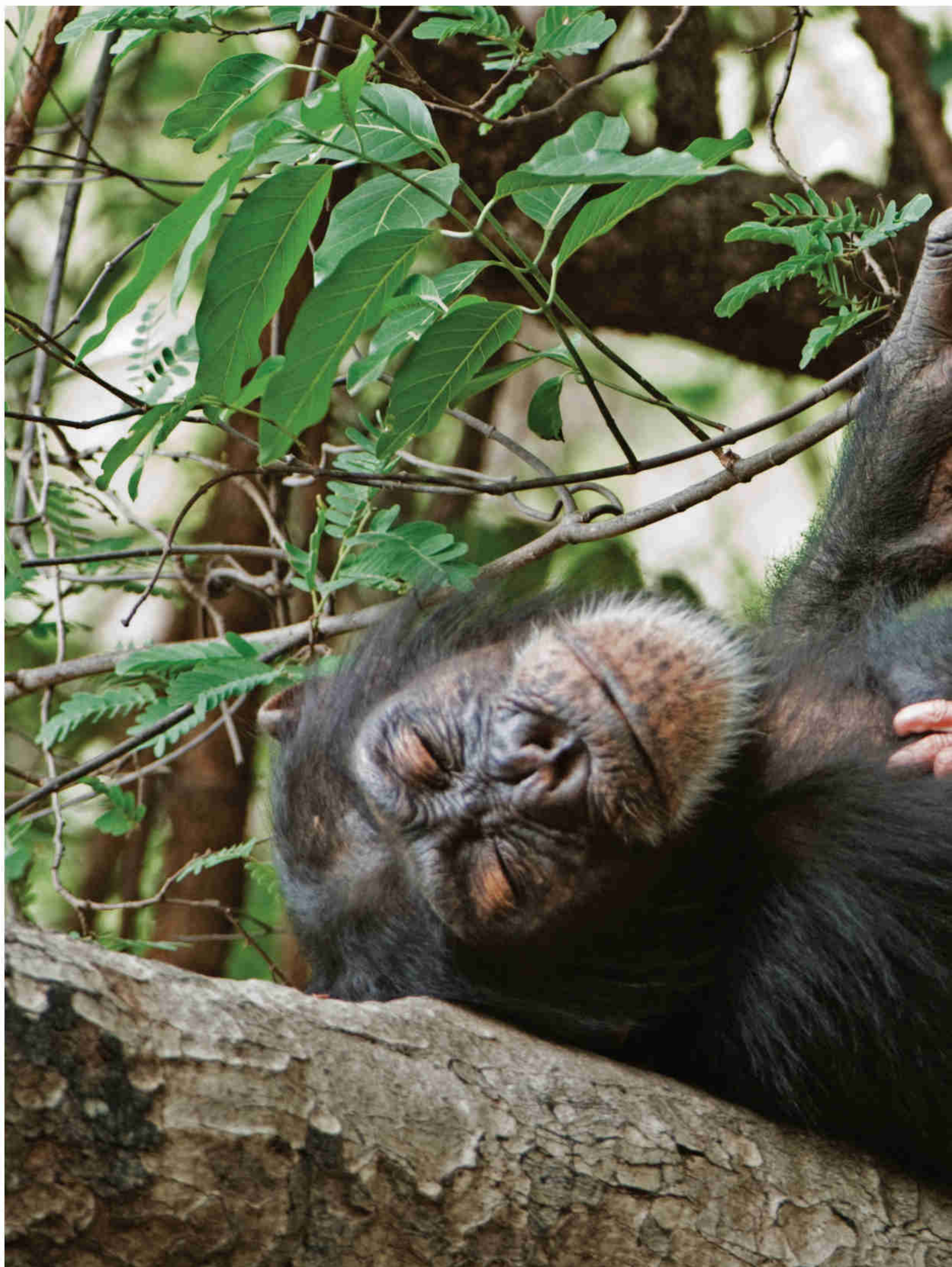




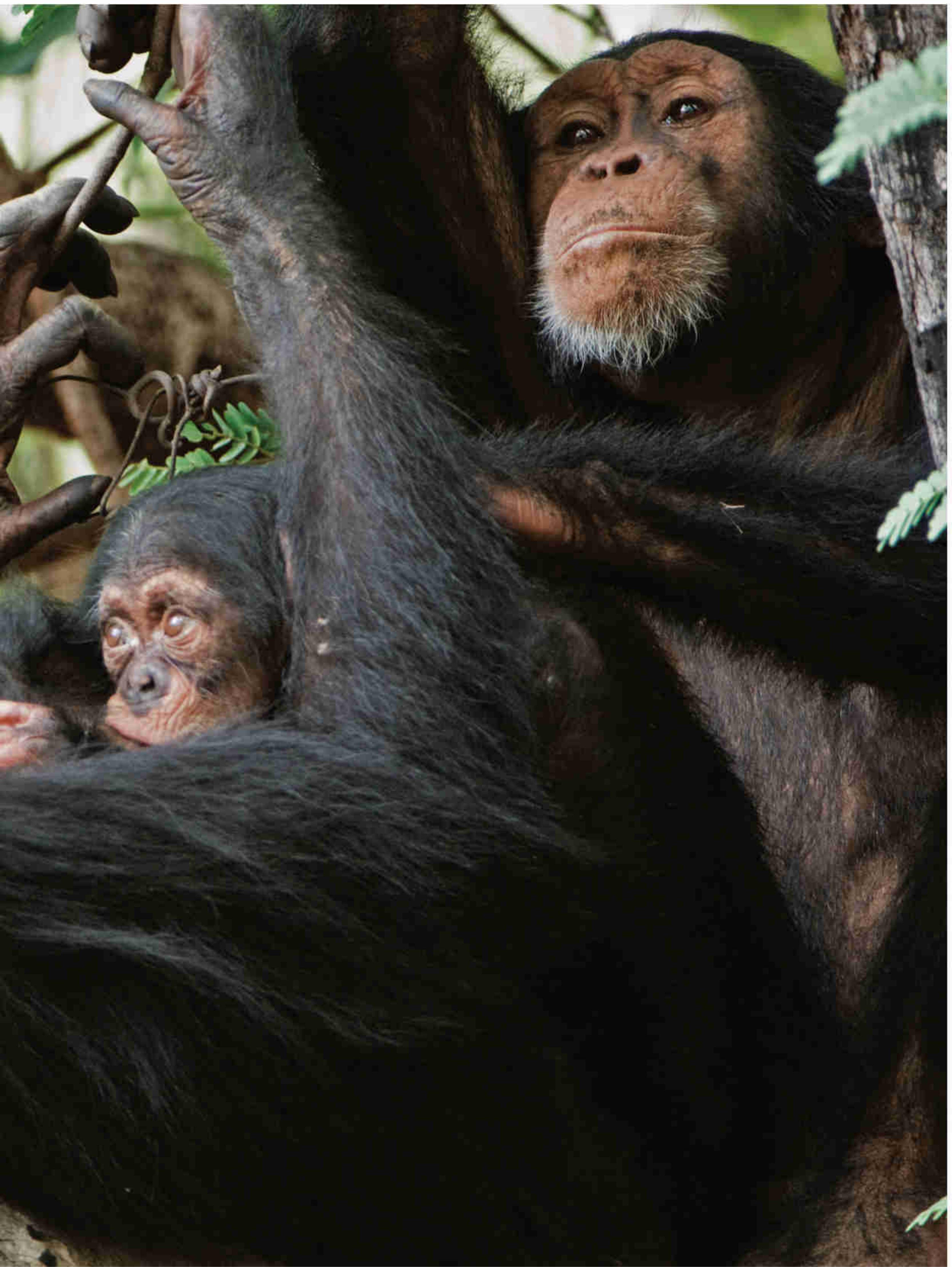
On the savannas of Senegal, chimpanzees are hunting bush babies with spearlike sticks. This hothouse of chimp “technology” offers clues to our own evolution.

Almost Human

An adult male lingers at Sakoto pool, a favorite spot among the community of chimps scientists call the Fongoli group, for a stream that runs through their range.



First-time mom Nickel reclines with her newborn, Teva, one of the newest members of the chimp group being studied at Fongoli. All the chimps clamored to groom the baby, but Nickel let Mike (at right), an orphan, get close. She avoided adult males, prone to noisy fits of branch shaking.





Savanna-woodland chimps, unlike their rain forest brethren, spend most of their waking time on the ground searching for food and water. Fongoli's mix of grassland, low trees, and a hot dry season mirrors the environment that eventually propelled early humans to hunt and use tools.



DAYBREAK IS SUDDEN and swift, as though an unseen hand had simply reached out and raised a dimmer switch. Cued by the dawn, thirty-four chimpanzees awaken.

They are still in the nests they built the previous night, in trees at the edge of an open plateau.

A wild chimpanzee does not get out of bed quietly. Chimps wake up hollering. There are technical names for what I'm hearing—pant-hoots, pant-barks, screams, hoos—but to a newcomer's ear, it's just a crazy, exuberant, escalating racket. You can't listen without grinning.

These are not chimps you've seen in these pages before. They're savanna-woodland chimps, found in eastern Senegal and across the border in western Mali. Unlike their better-known rain forest kin, savanna-woodland chimps spend most of their day on the ground. There is no canopy here. The trees are low and grow sparsely. It's an environment very much like the open, scratchy terrain where early humans evolved. For this reason, chimpanzee communities like the Fongoli group—named for a stream that runs through its range—are uniquely valuable to scientists who study the origins of our species.

By 8 a.m. my chintzy key-chain thermometer says it's 90 degrees. Our shirts are marked by the same white salt lines that appear on people's boots in winter. Here it's salt from sweat. The plateau we're crossing is a terrain of nothing, of red rocks and skin cancer, with no trees to break the fall of equatorial sun. In our backpacks we each carry three liters of water. It was cool when we set out. By noon it will be hot enough to steep tea.

I'm not complaining. I'm making a point. Life on the savanna—even so-called mosaic savanna, tempered by patches of lush gallery forest along the streambeds—is exceptionally harsh. If you are a primate used to greener terrain, you must adjust your behavior to survive. Our earliest hominin (meaning bipedal ape) ancestors evolved more than five million years ago during the Miocene, an epoch of extreme drying that saw the creation of vast tracts of grassland.

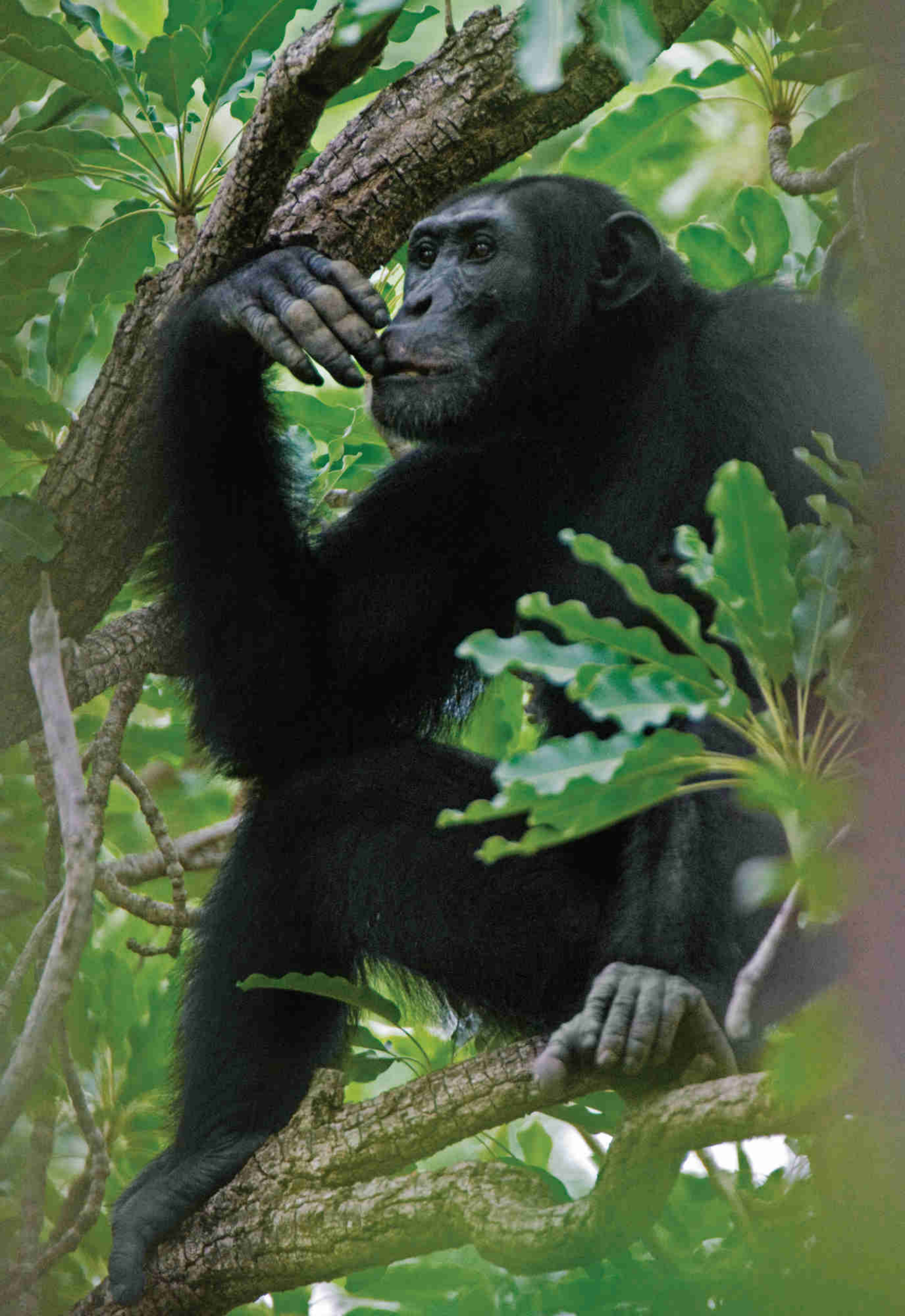
Tropical primates on the perimeter of their range no longer had plentiful fruits and year-round streams and lakes. They were forced to adapt, to range farther in their search for food and water, to take advantage of other resources. In short, to get creative.

In 2007 Jill Pruetz, an anthropologist at Iowa State University, reported that a Fongoli female chimp named Tumbo was seen two years earlier, less than a mile from where we are right now, sharpening a branch with her teeth and wielding it like a spear. She used it to stab at a bush baby—a pocket-size, tree-dwelling nocturnal primate that springs from branch to branch like a grasshopper. Until that report, the regular making of tools for hunting and killing mammals had been considered uniquely human behavior. Over a span of 17 days at the start of the 2006 rainy season, Pruetz saw the chimps hunt bush babies 13 times. There were 18 sightings in 2007. It would appear the chimps are getting creative.

There are individuals who are uncomfortable with Pruetz's tales of spear-wielding chimps, and not all of them are bush babies. Harvard professor of biological anthropology Richard Wrangham, who has studied chimpanzee aggression in Uganda's Kibale National Park, has been skeptical. Wrangham is widely known for his "demonic male" theory, which holds that the savage murders carried out by male chimps while policing their turf are suggestive of a violent nature at the core of man. Primatologist Craig Stanford, author of *The Hunting Apes*, also downplays the importance of Pruetz's findings. "This behavior is fascinating, but the observations are so preliminary that it merits only a short note in a journal."

The report ran in the major journal *Current Biology*, and people seemed to find it interesting. In the week that followed, Pruetz's findings were featured in more than 300 news and science outlets, including *New Scientist*, the *New*

Plotting his move? Lupin, a large teenage male, seems to have alpha ambitions, but chimp politics require more than brute strength—winning friends is critical.



York Times, the *Washington Post*, and NPR's *Science Friday*. The Smithsonian Institution requested one of the spears. In short, it was the most widely talked about primatology news since the reports of infanticide and cannibalism at Jane Goodall's site at Gombe in the 1970s.

Pruetz and I watch the chimps climb from their nests. A large male hangs from a low branch by one arm, swinging gently, in no hurry. The silhouette is utterly erect, arrestingly humanoid. He lets go, drops to the ground, and moves off across the plateau. The symbolism is impossible to miss. Here is a chimpanzee, thought by many to be the closest thing we have to a living model of our early hominin ancestors, literally dropping from the trees and moving out into the open expanses of the savanna. It is as though we are watching time-lapse footage of human evolution, the dawn of man unfolding in our binoculars.

CHIMPS THAT LIVE on the ground, rather than in the safety of treetops, tend to be wary of large strangers.

Jill Pruetz spent four years getting the Fongoli chimpanzees accustomed to the presence of humans—what primatologists call habituating them—and the past three summers observing them. Six days a week, from dawn to dusk, she follows the chimps.

It is not glamorous work. It's hot and filthy and exhausting. Home is a mud-walled hut and a drop toilet shared with 30 Fongoli villagers. Dinner is peanut sauce over rice, except when it's peanut sauce over millet. If the chimps wander unusually far, Pruetz gets back to the village so late that her portion has long ago been fed to the dogs. Sometimes, rather than hike the five miles back to camp, she curls up and sleeps on the ground (or takes a nap in an abandoned chimp nest). She has gotten malaria seven times.

Mary Roach is the author of Stiff and Bonk: The Curious Coupling of Science and Sex, due out this month. Frans Lanting is a wildlife photographer whose most recent book is Life: A Journey Through Time.

Yet you rarely meet people who love what they do as much as Pruetz does. Right now she is sitting on the ground, jotting notes with one hand and slapping sweat bees with the other. Blood from a blister has soaked through the heel of her sock. To listen to Pruetz, we might as well be in Paris. "Sometimes," she says, scratching a bite, "I think I'm going to wake up and it's all a dream." The payoffs have been dramatic. In addition to using tools to hunt, Fongoli chimps have been exhibiting some other novel behaviors: soaking in a water hole, passing the afternoon in caves.

At 24 square miles, Fongoli is the largest home range of any habituated chimpanzee group ever studied. (Jane Goodall's Gombe chimps, by comparison, roam over five square miles.) Craig Stanford likens foraging over a large range to knowing one's way around an enormous supermarket. Like Pruetz, he believes the chimpanzees are not foraging at random, but moving with foresight and intent. "You don't stroll down the aisles hoping to catch a glimpse of the broccoli. You know where each item is, and in which months seasonal foods are likely to be in stock." The same, he thinks, holds true for chimpanzees.

"Ecological intelligence" is the name of the theory that some primates, including those of our lineage, have evolved larger, more complex brains because it helped them adapt to the challenges of surviving in a less giving habitat. "The first push toward a larger brain," writes Stanford, "may have been the result of a patchily distributed, high-quality diet and the cognitive mapping capabilities that accompanied it."

High-quality, meaning: meat. The shift toward eating more meat may have played an important role in the evolution of a larger, more sophisticated brain. Here's how the thinking goes. Brains are, to use terminology coined by researchers Leslie Aiello and Peter Wheeler, "expensive tissue." To keep a bigger brain functioning, some other organ or system needed to become more streamlined. A chimp doesn't have to eat nearly as much of an energy-rich food like meat as he would of low-nutrient plant matter. Expending less energy on digestion means you can afford to apply it

elsewhere, perhaps to power an expanded brain.

As if on cue, a female named Tia appears in our sight lines 20 feet ahead, sitting on a boulder pulling raw flesh off a limb like a picnicker with a comically huge drumstick. Pruetz raises her binoculars, then lowers them again. “Holy crap! It’s a bushbuck.” She can tell from the white markings on the hide, a long strip of which hangs from the leg. “That’s the biggest animal I’ve seen them eat.” She surmises it was a fawn. Gombe chimps have occasionally killed bushbuck fawns as well. They are the largest prey on record for a chimpanzee.

Hunting at Fongoli coincides with the rainy season, and Pruetz has some theories about why this is. As water holes fill and shoots and other greenery become more plentiful with the rain, the land provides enough sustenance to support a sizable group of chimps on the move. There are advantages to traveling in a large group. A single chimp or small group that heads out on its own can easily lose track of the community for days at a time. For a chimp, sociability is important. Pruetz points to an estrous female named Sissy, her pink swelling bobbing behind her like a bustle. “Otherwise you miss out on that.” She means, of course, the chance to mate, to pass along your genetic material.

Right now, two rains into the rainy season, there’s enough water and food for the group to travel together, but just barely. Pruetz believes it is this scenario—large crowd competing for limited resources—that has pushed certain members of the community to try their hand at novel things.

Things like sharpening sticks to spear bush babies. It is a different kind of hunting than the organized colobus monkey raids documented at other sites. A chimp who comes across a dead, hollow tree limb—promising real estate for day-sleeping bush babies—will sometimes break off a branch from a nearby tree, remove the leaves and the flimsy ends, and then use its teeth to whittle one end to a point. This tool is then stabbed into an opening in the tree limb until the animal inside is out of commission. Whereupon it is eaten, head first, Pruetz says, “like a Popsicle.”

Adult female and juvenile chimps—the low

rankers—have been seen hunting bush babies most often. This makes sense. Dominant males are not generous with food they find, and no one can force them to share. Fongoli females appear to have taken matters into their own hands.

Now here comes Farafa, her baby Fanta on her back and a bushbuck haunch in her jaws. It’s a complicated, messy piece of anatomy, with sinew and hide hanging off one end. Tia sees her and stands up to move away. My last glimpse of Tia is with her now bare bone brandished above her head, standing erect, as though reenacting the “dawn of man” scene from *2001: A Space Odyssey*. Fongoli chimps have a flair for the dramatic.

THE MEDIA RUCKUS spurred by Pruetz’s report of spear-wielding chimps made her absence as a speaker at last year’s Mind of the Chimpanzee conference perplexing.

She was in the audience but wasn’t invited to present a paper. On top of that, Pruetz’s post-doc adviser, Cambridge University primatologist William McGrew, made a passing reference to the Fongoli hunting behaviors but did not credit her with the work. He credited her co-author and former student Paco Bertolani, now a student of McGrew’s. Bertolani witnessed the first—of now 40—observed instances of the behavior, but scientific etiquette would call for the principal investigator to be mentioned. McGrew apologized afterward. Some primatologists took Pruetz to task for overstating the bush-baby-spearing behavior. When your prey is smaller than your hand, are you really hunting? Male primatologists tend to make the distinction along gender lines: The traditional view has been that chimpanzee hunting—along with aggression and murder—is the domain of the male. “Small mammals that females and juveniles obtain are ‘gathered,’” Pruetz says, “while males ‘hunt.’” Females, the thinking goes, don’t hunt because they don’t need to; male chimps are thought by some to trade meat



Primatologist Jill Pruetz holds one of the first known “spears” used by a chimp. She made headlines with her report of chimps hunting bush babies by jamming modified sticks into tree-hole burrows (right). The technique appears to be used most often by females and the young, which may engineer new foraging methods when food is scarce and males refuse to share.

for sex, but Pruetz hasn’t seen this at Fongoli.

I’m going to weigh in, for what it’s worth. One day while accompanying Pruetz, I watched a young chimp named David at a bush baby tree hole. We heard him well before we saw him: a resounding *THONK* that caused Pruetz to stop in her tracks and go, “Hold on, hold the phone, that sounds like a spear!” We looked around, and there he was, standing on a branch in a kino tree, holding on with one hand and waving a thick, three-foot-long stick over his head. He slammed it down into the hole, then examined the tip. Concluding that no one was home, he took off, leaving the spear protruding from the hole. The violence and foresight with which he undertook his task did not suggest an animal quietly foraging. His aim was unmistakable: to kill, or at least incapacitate, whatever was in there.

Many of Pruetz’s reviewers tripped over the word spear. For one thing, it suggests a projectile and a more Cro-Magnon-esque technique: something aimed and thrown. (Pruetz says she had spearfishing in mind when she chose the noun.) Stanford suggested bludgeon. But bludgeons

are blunt, not sharpened. Another offered dagger. Someone else wanted bayonet. In the end, Pruetz took spear out of the title and worded her text more cautiously, making reference to a tool “used in the manner of a spear.” (The press picked up on it anyway. “Spear-Wielding Chimps Snack on Skewered Bushbabies” ran the giddy *NewScientist.com* headline.)

I asked Pruetz if perhaps she’s been the victim of an alpha male primatologist conspiracy. She laughed it off. “Yeah, maybe I’m not pant-grunting enough.” (The pant-grunt is an expression of submissiveness; a chimp that encounters a higher ranked peer and fails to pant-grunt is asking for trouble.) It’s also possible that humans are simply resistant to the notion that anyone other than a human makes weapons for killing.

You would think that primatologists, more than other scientists, would be comfortable with the shifting boundaries between chimpanzee and human. Their gene sequences are around 95 to 98 percent the same. (This is less meaningful than it sounds. Humans share more than 80 percent of their gene sequence with mice, and maybe 40 percent with lettuce.) A recent exploration of the human and chimpanzee genomes, undertaken by David Reich and colleagues at

■ **Society Grant** This research project is supported by your Society membership.



CHIMP CULTURES

Just as humans use chopsticks in one culture and forks in another, scientists now realize that chimpanzees also develop different cultural practices depending on where they live. Chimpanzees in ten well-studied sub-Saharan communities have devised the following variations on common behaviors.

► Use of hammer and/or anvil

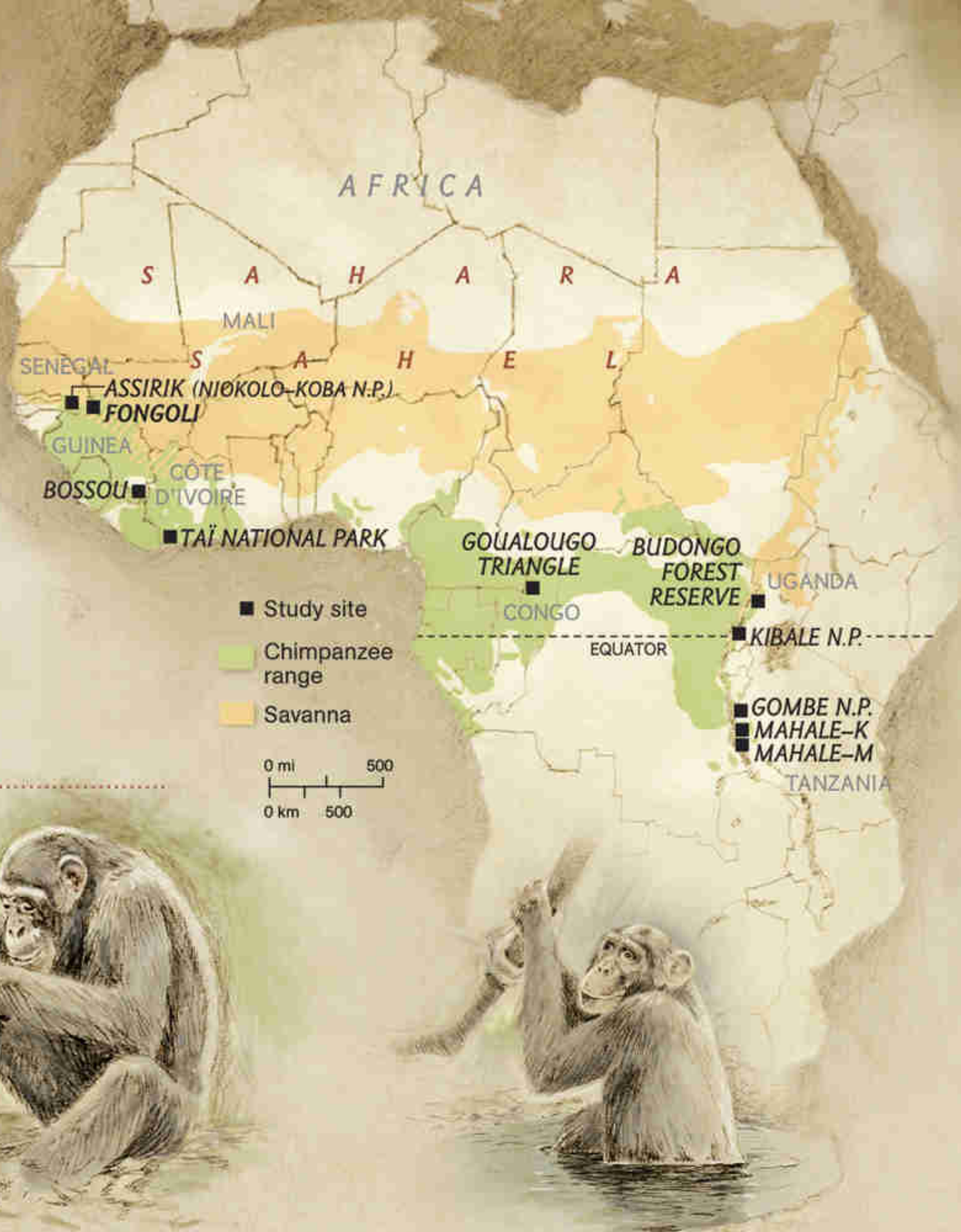
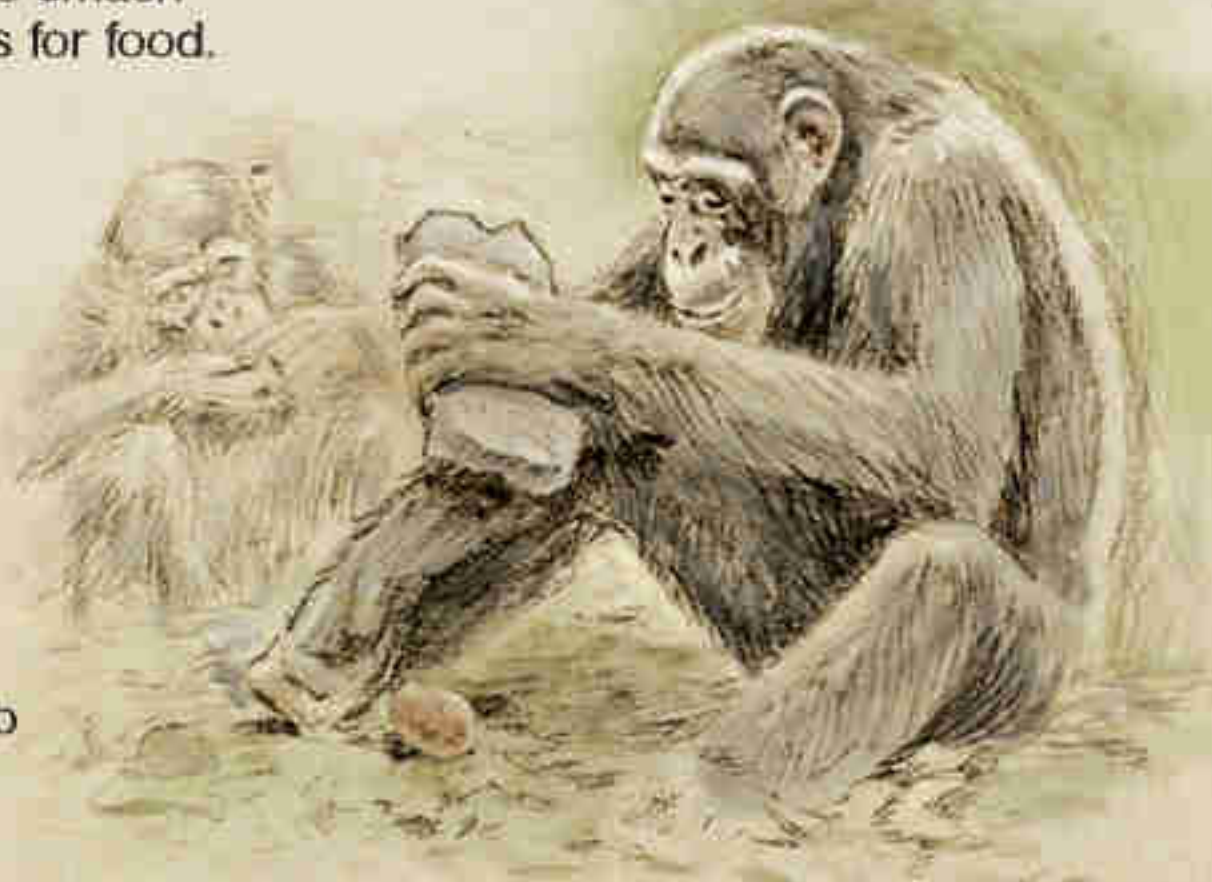
Chimps use rocks to smash open nuts and fruits for food.

WHERE

- Fongoli
- Assirik
- Bossou
- Gombe
- Tai

VARIATION

Tai chimps also use wood to crack nuts. Fongoli and Assirik chimps slam baobab fruit against rocks.



▼ Leaf sponge

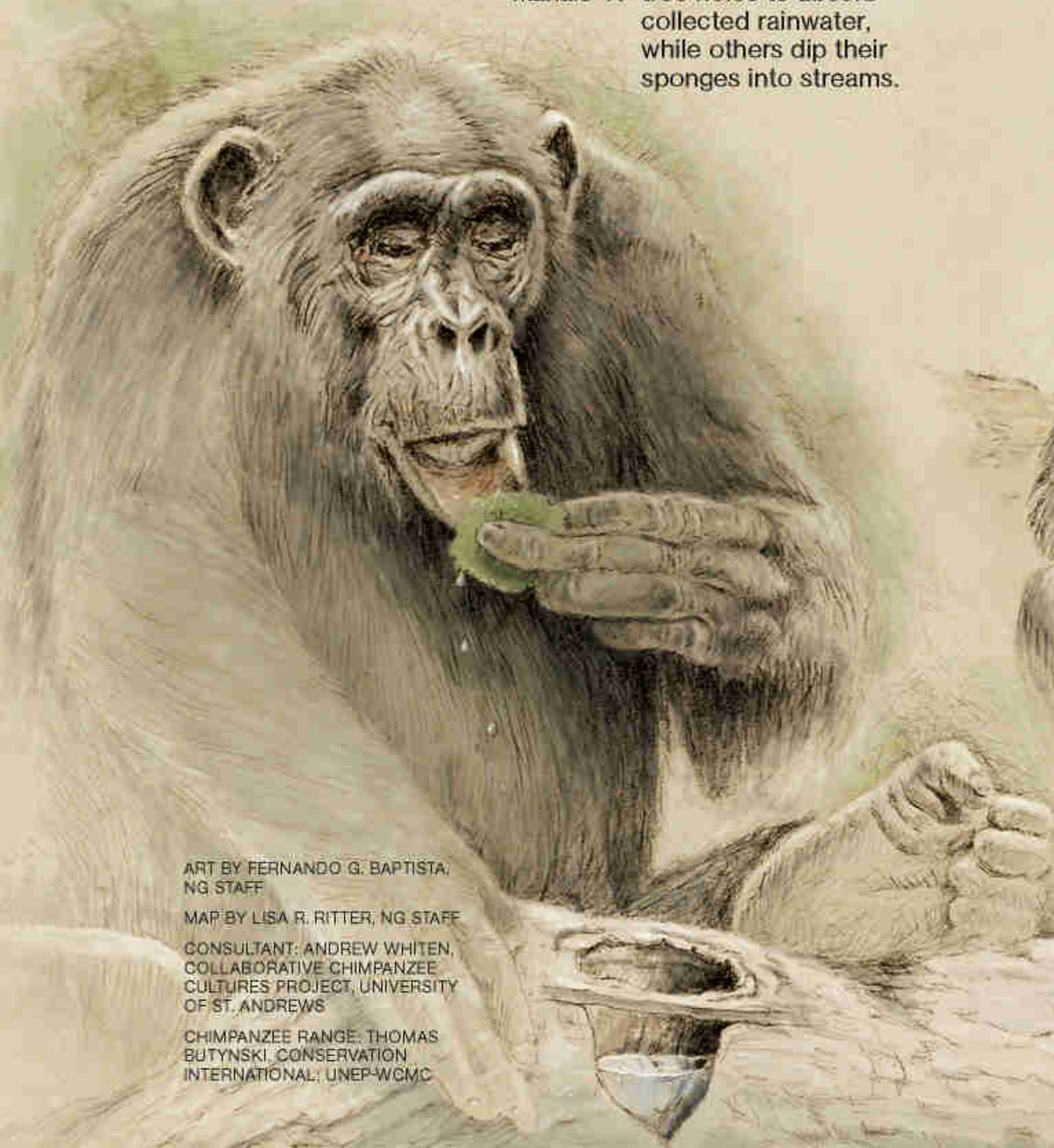
Chimps chew leaves into spongy wads to soak up water for drinking.

WHERE

All sites except Mahale-K

VARIATION

Chimps in some groups poke leaf sponges into tree holes to absorb collected rainwater, while others dip their sponges into streams.



▲ Going into water

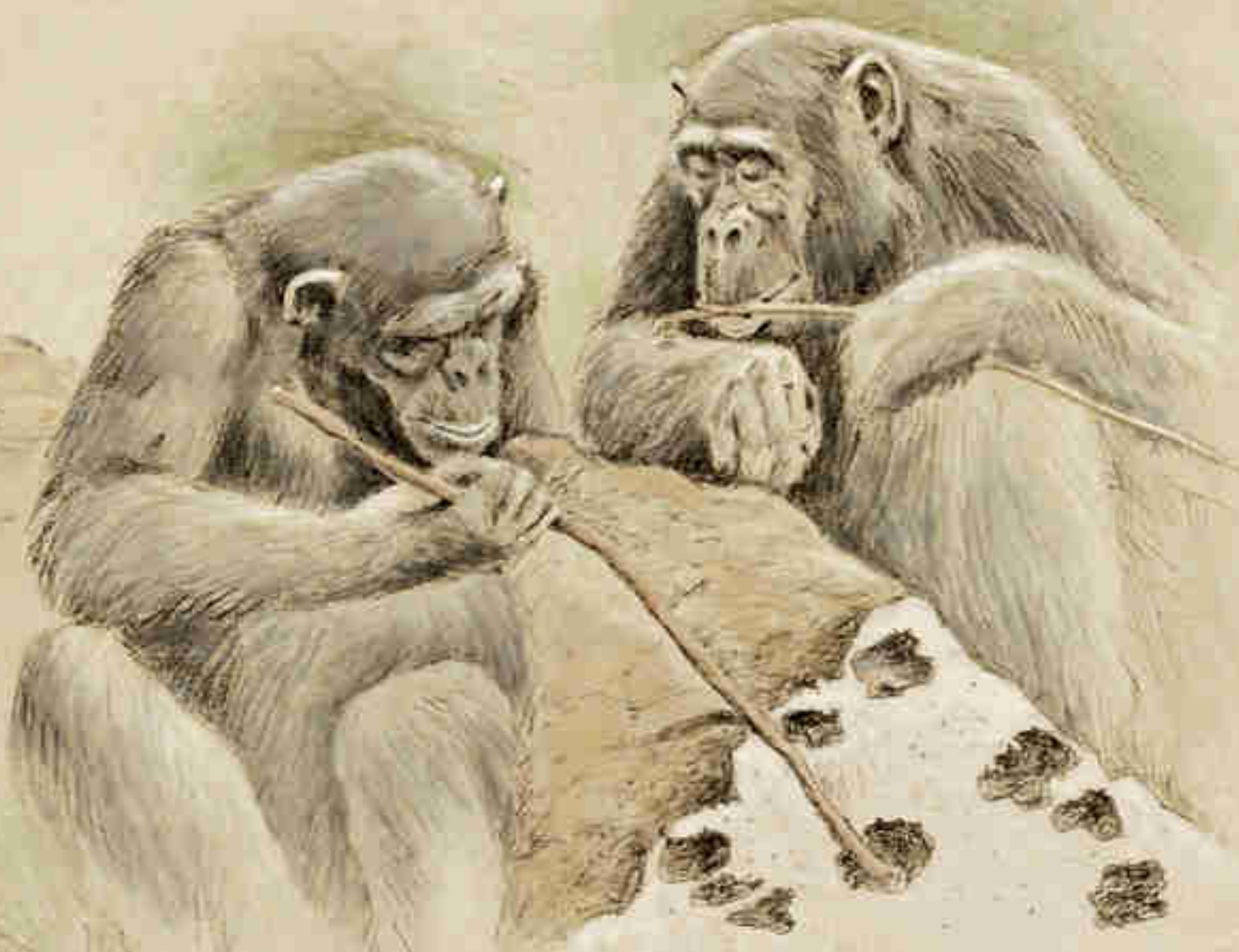
Chimps in most communities avoid major contact with water, but three groups enter streams or pools.

WHERE

- Fongoli
- Bossou
- Mahale-M

VARIATION

At Fongoli chimps sit in waist-high water or lie in shallow pools. Bossou chimps wade but don't sit down. Mahale chimps display by splashing.



▲ Termite fishing

Chimps often use twigs, grass, or vines to fish termites from mounds.

WHERE

- Fongoli
- Gombe
- Goualougo
- Mahale-K

VARIATION

Apes get larger helpings of termites at Fongoli and Goualougo by first fraying the end of their fishing tools to create more surface space to snag the bugs.

ART BY FERNANDO G. BAPTISTA, NG STAFF
MAP BY LISA R. RITTER, NG STAFF
CONSULTANT: ANDREW WHITEN, COLLABORATIVE CHIMPANZEE CULTURES PROJECT, UNIVERSITY OF ST. ANDREWS
CHIMPANZEE RANGE: THOMAS BUTYNSKI, CONSERVATION INTERNATIONAL; UNEP-WCMC



◀ Rain dance

A storm can provoke chimps in most groups to show off with a frenetic or rhythmic display.

WHERE
All sites (though unconfirmed at Assirik)

VARIATION
Before a storm Tai chimps perform a slow and often silent dance.

▼ Rock throwing

Rocks are hurled, sometimes as weapons and other times as part of a display.

WHERE
All sites except Budongo and Goulougo

VARIATION
Mahale males tend to throw rocks into water as part of their displays.

◀ Hunting

Across cultures, males do most of the hunting, catching monkeys and other small game with their bare hands.

WHERE
All sites except Goulougo

VARIATION
At Fongoli it's mostly females and juveniles that sharpen sticks to stab at bush babies.



▼ Leaf clipping

Chimps often bite off bits of leaves and spit them out to get each other's attention or show anxiety.

WHERE
• Fongoli
• Bossou
• Kibale
• Mahale-K
• Mahale-M
• Tai

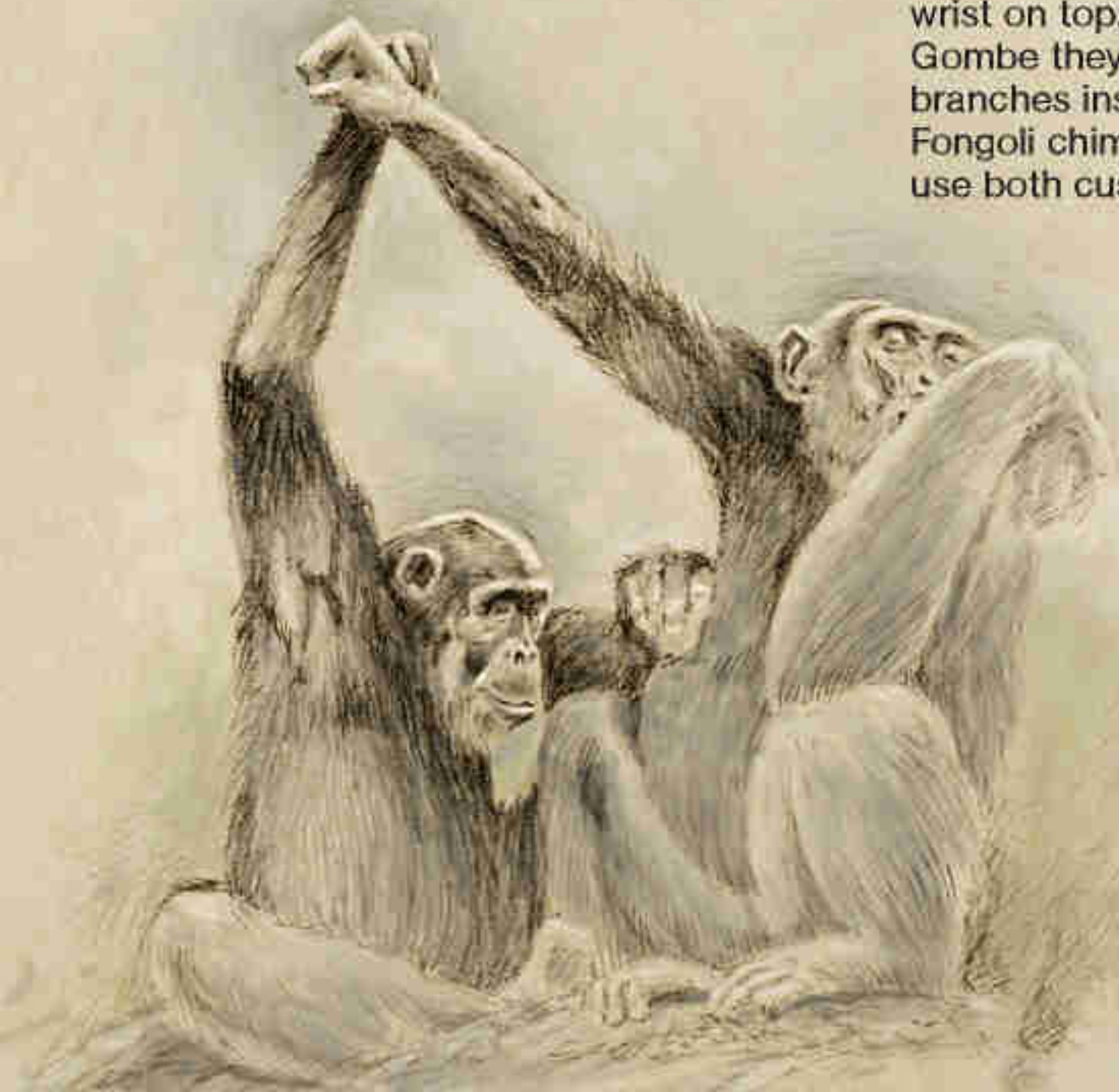
VARIATION
Mahale chimps also clip leaves during courtship, while at Fongoli and Tai, males usually clip leaves before a display. Fongoli females do it when they have hiccups.

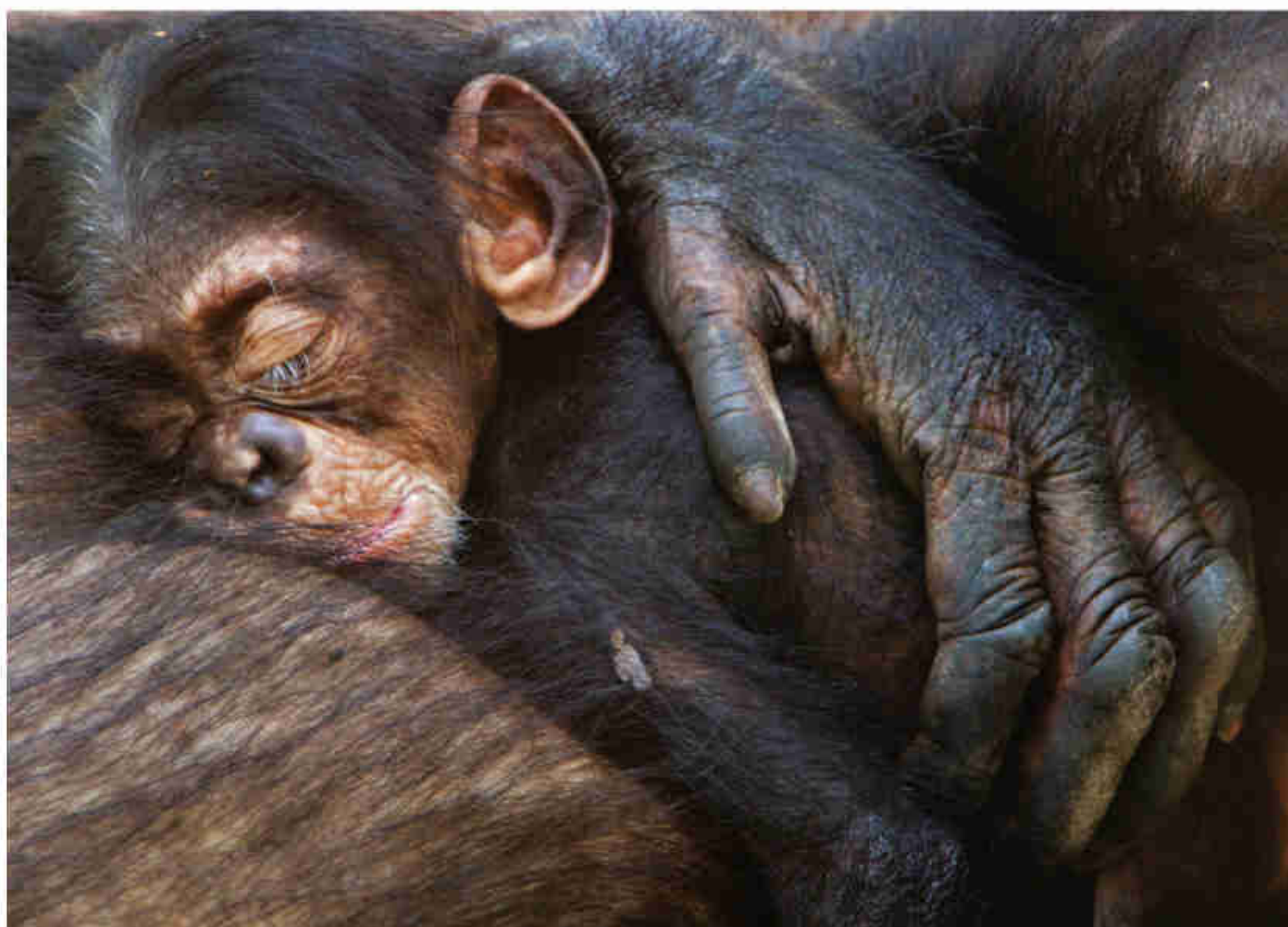
▼ A-frame grooming

Several groups hold hands over their heads while grooming.

WHERE
All sites except Bossou and Budongo

VARIATION
Mahale chimps grasp palms or wrists, with the dominant chimp's wrist on top. At Gombe they hold branches instead. Fongoli chimps use both customs.





The only infant born in the Fongoli group last spring, Teva is the first baby scientists were able to track within a week or two of her birth. Closely monitoring her development will provide valuable insights into how chimps pass on behaviors. “Her mother is one of the most prolific hunters,” says Pruetz. “It will be interesting to see if Teva picks it up.”

the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, suggests that chimpanzees and early hominins may have interbred after the two lines initially split. Yet there seems to be a lingering discomfort with findings that, as Pruetz puts it, “chip away at our superiority.”

Since the earliest days of primatology, discoveries of chimp behavior that threaten to undermine the specialness—the apartness—of human beings have met with rancorous resistance. Many anthropologists bristled at the first references to chimpanzee “culture”—a concept widely accepted today. Jane Goodall’s first reports of chimps making tools (for termite fishing) were as contentious in their day as more recent claims of teaching chimps to use language. At the Great Ape Trust, in Des Moines, Iowa, a bonobo named Kanzi has learned to communicate through symbols. Kanzi commands about 380 symbols and shows signs of understanding their meaning. When he was frightened by a beaver, an animal for which he had no symbol, he selected the symbols for “water” and “gorilla” (an animal that scares him). Critics say the communications are purely conditioned behavior. Novel uses of symbols—e.g., “water gorilla”—are dismissed as coincidence.

An exception to these attitudes has long been found at the Primate Research Institute at Kyoto University. Japanese primatology is consistent with the Buddhist precept that humans are a part of the natural world, not above or separate from it. At the Mind of the Chimpanzee conference in Chicago last year, Tetsuro Matsuzawa spoke of primatology’s early years, when scientists “didn’t know how much close we are.” He added, with unabashed awe: “So close, like horse and zebra.” In the background of one Japanese researcher’s slides was what looked to be a chimp wearing glasses. I turned to the man next to me. “I’m sorry,” I said. “I must be losing my mind. Was that chimp wearing glasses?” The man told me the Japanese primatologists had noticed the chimp was nearsighted and had him outfitted with prescription lenses. (I later learned he was wrong: This chimp was just playing with the glasses. There once was a research chimp whose caretakers ordered her glasses, but that was in the U.S., not Japan.)

No one around Fongoli is sending chimps to the optician, but the animals are accorded a remarkable amount of respect by locals. Kerri Clavette, Pruetz’s intern, interviewed villagers about their beliefs regarding chimpanzees and

whether they hunted them. Among the region's main tribes—the Malinke, Bedik, Bassari, and Jahanka—chimps, compared with monkeys, have an elevated, almost human status. “Chimpanzees came from man, as they have similar hearts,” a villager told Clavette. Behaviors normally associated with a baser nature—such as walking on all fours—were given a respectful spin: “Chimpanzees walk on their knuckles to keep their hands clean to eat with.” Chimpanzee origin myths feature humans running off into the woods for some reason—war, fear of circumcision, fear of being punished for fishing on Saturday—and staying there so long that they turn into chimpanzees.

Despite a local history of killing chimpanzees for medicinal reasons—the meat laid on a person's arm or eaten for strength, the brains prepared with couscous to treat mental illness—villagers rarely hunt chimpanzees in eastern Senegal today. Sadly, the taboo against eating one's almost kin has broken down in central Africa, where turmoil has worsened dire economic circumstances and chimps are sold as bush meat.

Attitudes in the West have been shifting gradually over the past few decades. The sequencing of the chimp genome, completed in 2005, has focused attention anew. New Zealand, the Netherlands, Sweden, and the United Kingdom have all passed legislation limiting experimentation on great apes, and the Balearic Islands in Spain passed a resolution in 2007 granting them basic legal rights. In 2006 an Austrian animal rights organization submitted an application to a district court in Mödling to appoint a legal guardian for a chimp named Hiasl. The strategy was to establish “legal person” status for the hairy defendant. (The judge was sympathetic but refused.) It is perhaps less problematic to view the situation as does *The Third Chimpanzee* author Jared Diamond: not that chimps are a kind of human, but that humans are a kind of chimp.

THE CHIMP NAMED SISSY sits motionless and hunched at a low termite mound twenty feet from us.

Only her right arm moves, pushing a saba vine probe into a hole and gently withdrawing it,

with termites clinging to it. She raises it carefully to her mouth like a pensioner spooning soup. The mound is across an open lay of pebbly, brick-colored laterite that gives the ground the look of a clay tennis court.

Like fly-fishing, termite fishing is a meditative, deceptively nuanced activity. I tried it a few times and could not even find an active hole. My probe never sinks farther than an inch or so; the chimps regularly bury theirs a foot or more. They can find active holes by smell, inserting a probe and then sniffing the end of it for the smell of soldier termite pheromone.

Fongoli chimps eat termites year-round, not just in the dry season, when other foods are scarce. Termites make up, at bare minimum, 6 percent of the Fongoli chimps' diet. We know this because most evenings at six o'clock research assistant Sally Macdonald sits down with a set of sieves and buckets, and one or two ziplock bags of the chimp feces that the researchers bring back most days. She scans the fruit seeds, estimates the percentage of fiber from leaves and shoots, and takes note of bones and termite pincers. “Science in all its glamour,” deadpans Macdonald, whose mother sends ziplock bags but does not know their fate.

A quick glimpse into the bucket reveals that saba fruit is the chimps' mainstay this time of year, an adult averaging 30 to 40 a day. The Fongoli record for saba seeds in a single fecal sample—499, compared with an average of 75—probably belongs to a male named Mamadou. Which may explain why Mamadou is, quoting Pruetz, “especially gassy.”

Pruetz's Ph.D. student Stephanie Bogart says part of the reason chimps fish termites is that they're an exceptionally calorific food. A 3.5-ounce serving of termites has 613 calories, compared with chicken's 166. But 3.5 ounces of soldier termites is hundreds of insects, fished piecemeal from a mound. It's like eating cake one crumb at a time. The chimps must really like them.

Sissy gets up from her spot at the termite mound to select a new tool. She breaks off a length of vine, inspects it. Satisfied, she sticks it in her mouth and carries it back to the mound



Most chimps avoid getting in water, but Fongoli males seek out pools to escape the 110-degree heat. "Pools are like the North Star for finding the chimps," says Pruetz. "They use them as a base and radiate out from them when they forage." The pile of rocks at right hides a camera.





Nellie, a young female, grips a limb with her feet as she tightropes some 30 feet above the forest floor. Chimps feature curved toe bones (right) that help them grasp trees and vines as they navigate the forest canopy. Observing apes walking on branches has led some scientists to speculate that bipedalism may have actually arisen in trees rather than on the ground.



like a seamstress holding pins between her lips. Pruetz and others argue that female chimps are not only more skilled than males at crafting and using tools, but also more diligent. Craig Stanford agrees that it might well have been our female ancestors who first steered the culture toward tool use. Early tools for foraging, he imagines, gave way to tools for scavenging meat from carcasses killed and abandoned by large carnivores. These tools in turn may have paved the way for implements for killing prey. Which makes Pruetz's observations of chimps sharpening sticks and using them to whack bush babies all the more arresting: Fongoli's females seem to have skipped ahead to the killing tools. Barbecue tongs can't be all that far behind.

PRUETZ AND I are sitting along a forested ravine where the chimps rest during the day's hottest hours.

The vegetation is thicker here. We watch a slender green vine snake move through the grass. Birds are calling over our heads. One says *cheerio*; one actually says *tweet*. A third says *whoop whoop whoop whoop whoop*, like Curly of the

Three Stooges. (When I ask what that one is, Pruetz replies, not at all sarcastically: "a bird." She is a woman of singular interests.)

Pruetz directs my gaze to a tangle of saba vines. Where I see a dark mass, she is able to distinguish six animals. The woman has chimp vision. (It's a condition that lingers long after she gets back to Iowa. "I get home and I'm looking for chimps on campus.") The animals can be so well hidden and so quiet that even Pruetz has trouble finding them. She sometimes locates them by smell—"chimp" being a potent variant of B.O. "Yesterday I thought I smelled chimp," Pruetz says, "but it was me."

The scene in the vines is one of drowsy, familial contentment. Yopogon is grooming Mamadou. Siberut is leaning against a tree trunk, rubbing his two big toes together, as he often does. A pair of youngsters swing on vines, flashing in and out of an angled shaft of sun. One uses a foot to push off from a tree trunk, spinning himself around. The other swings from vine to vine,

🦋 **Next of Kin** Witness Fongoli chimpanzees in action as they make and use sharpened sticks to hunt for bush babies in video clips at ngm.com.

Tarzan-style. They are almost painfully cute.

A chimp called Mike lies on his back in a hammock of branches, legs bent, one ankle crossed atop the opposite knee. One arm is behind his head, the other is crooked at the elbow, the hand hanging slack from the wrist, in the manner of a cowboy slouched against a fence. We stare at each other for a full ten seconds. Partly because his pose is so familiarly human and partly because of the way he holds my gaze, I find myself feeling a connection with Mike.

I confess this to Pruetz, who admits to similar feelings. She cares about the Fongoli chimps as one cares about family. She sends excited emails when a baby is born and worries when the elderly and nearly blind Ross disappears for more than a week. But she does not reveal this side of herself at conferences. There it's all lingo and statistics, pairwise affinity indexes and "blended whimper pouts." "Especially with male chimp researchers," she says.

One of the first things primatology students are taught is to avoid anthropomorphism. Because chimps look and act so much like us, it is easy to misread their actions and expressions, to project humanness where it may not belong. For example, I catch Siberut looking toward the sky in what I take to be a contemplative manner, as though pondering life's higher meaning. What he's actually pondering is life's higher saba fruits. Pruetz points some out in the branches above Siberut.

YET IT IS IMPOSSIBLE to spend any time with chimpanzees and not be struck by how similar they are to us.

I've been keeping a list of things I have seen or read or heard Pruetz say that drive home this point in unexpected ways. I had not known that chimpanzee yawns are contagious—both among each other and to humans. I had known that chimps laugh, but I did not know that they get upset if someone laughs at them. I knew that captive chimps spit, but I hadn't known that they, like us, seem to consider spitting the most extreme expression of disgust—one reserved,

interestingly, for humans. I knew that a captive ape might care for a kitten if you gave one to it, but had not heard of a wild chimpanzee taking one in, as Tia did with a genet kitten. The list goes on. Chimps get up to get snacks in the middle of the night. They lie on their backs and do "the airplane" with their children. They kiss. Shake hands. Pick their scabs before they're ready.

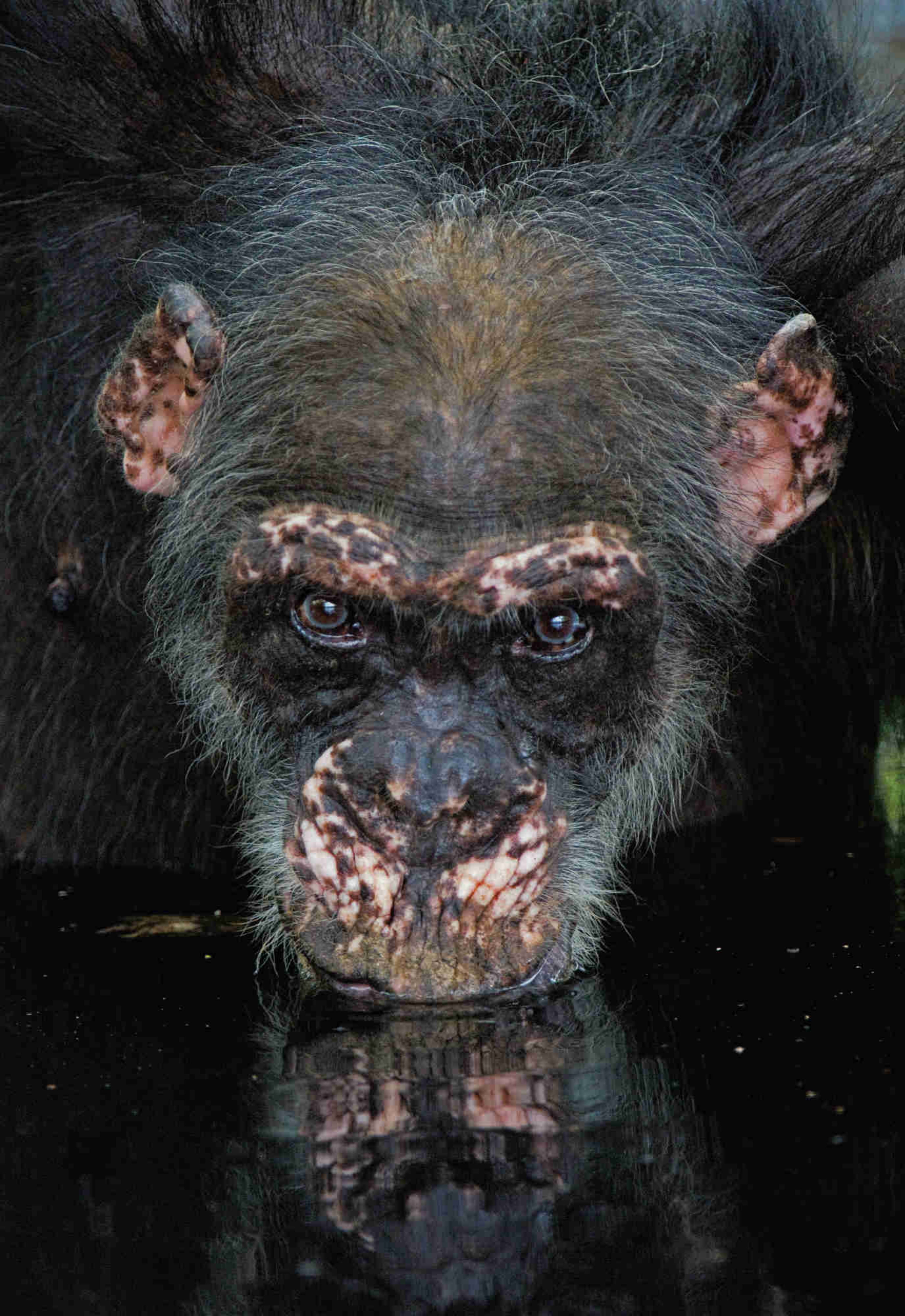
The taboo on anthropomorphizing seems odd, given that the closeness—evolutionary, genetic, and behavioral—between chimpanzees and humans is the very reason we study chimps so obsessively. Some thousand-plus studies have been published on chimpanzees. As a colleague of Pruetz's once said to her, "A chimp takes a crap in the forest, and someone publishes a paper about it." (No exaggeration. One paper has a section on chimpanzees' use of "leaf napkins": "This hygienic technology is directed to their bodily fluids (blood, semen, feces, urine, snot)... Their use ranges from delicate dabbing to vigorous wiping.")

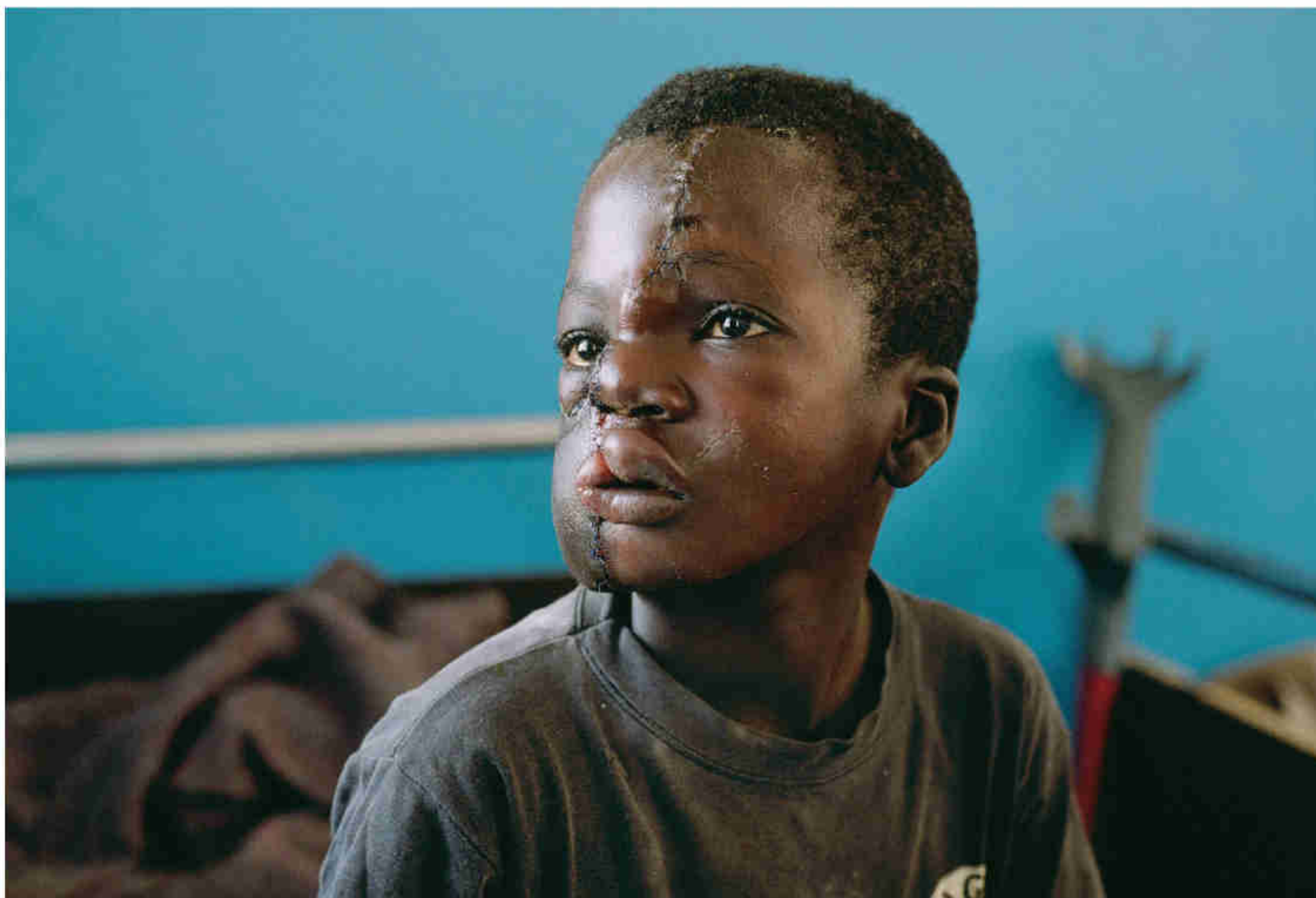
As for the chimps, they are not nearly as intrigued by the ape-human connection. While we've been observing them, they have largely ignored us, occasionally shooting a glance over one shoulder as they move through the brush. There is no fear in this glance, but neither is there curiosity or any sort of social overture. It is a glance that says simply, *Them again.*

Even Mike. He just turned away from my gaze and pointedly, or so it seemed, rolled over to turn his back on me. In hindsight I would have to say that the reason Mike had been looking at me was that I happened to be in his line of vision.

The chimps begin making their nests, breaking off leafy branches and dragging them into the treetops. Pruetz will wait until all are bedded down before turning to head back. We sit and listen to their "nest grunts"—soft, breathy calls that seem to express nothing more than the deep contentment one feels at the end of a day, in a comfortable bed. □

Almost blind, deaf, and toothless, Ross is probably in his 40s and too old to hunt. He survives by pounding open fruits—proof that innovation isn't just for the young.





Doctors in Niger reconstructed Noufou Tapsoba's face after the boy's bout with noma.

THE SAHEL, PAGE 34 **Stopping Noma** It starts as a sore in the mouth. Then, quickly, noma—a gangrenous infection that thrives where poor sanitation and malnutrition are common—eats through facial muscles, cartilage, and skin, leaving a wound that often gapes open to the bone. More than 100,000 children worldwide have noma; the rate in sub-Saharan Africa is as high as 1 in 1,000 a year. Most victims are children, and over 70 percent die from the disease. Photographer Pascal Maitre met 12-year-old Noufou Tapsoba (above) in Niamey, Niger. Sentinelles, a Swiss NGO specializing in noma care, had brought the boy to a hospital there for reconstructive surgery; more operations followed Maitre's visit. Though no one knows exactly what causes noma, the disease is treatable if caught in time—and preventable with proper nutrition and health care. These groups are trying to stop its spread:

■ **Sentinelles** works to prevent noma and expedites surgery for disfigured children. Checks made out to the group should include its account number (CCP 10-4497-9) and be sent to Sentinelles, Les Cerisiers, Route de Cery, 1008 Prilly, Switzerland. For more information go to sentinelles.org (the site is only in French).

■ **The University of Maryland Dental School** offers dental care to noma-prone kids in Africa. Contributions (payable to UMB Foundation, Inc., specifying "Noma Research and Treatment Fund") should be directed to the University of Maryland Dental School, Office of the Assistant Dean of Finance, 650 W. Baltimore St., Baltimore, MD 21201.



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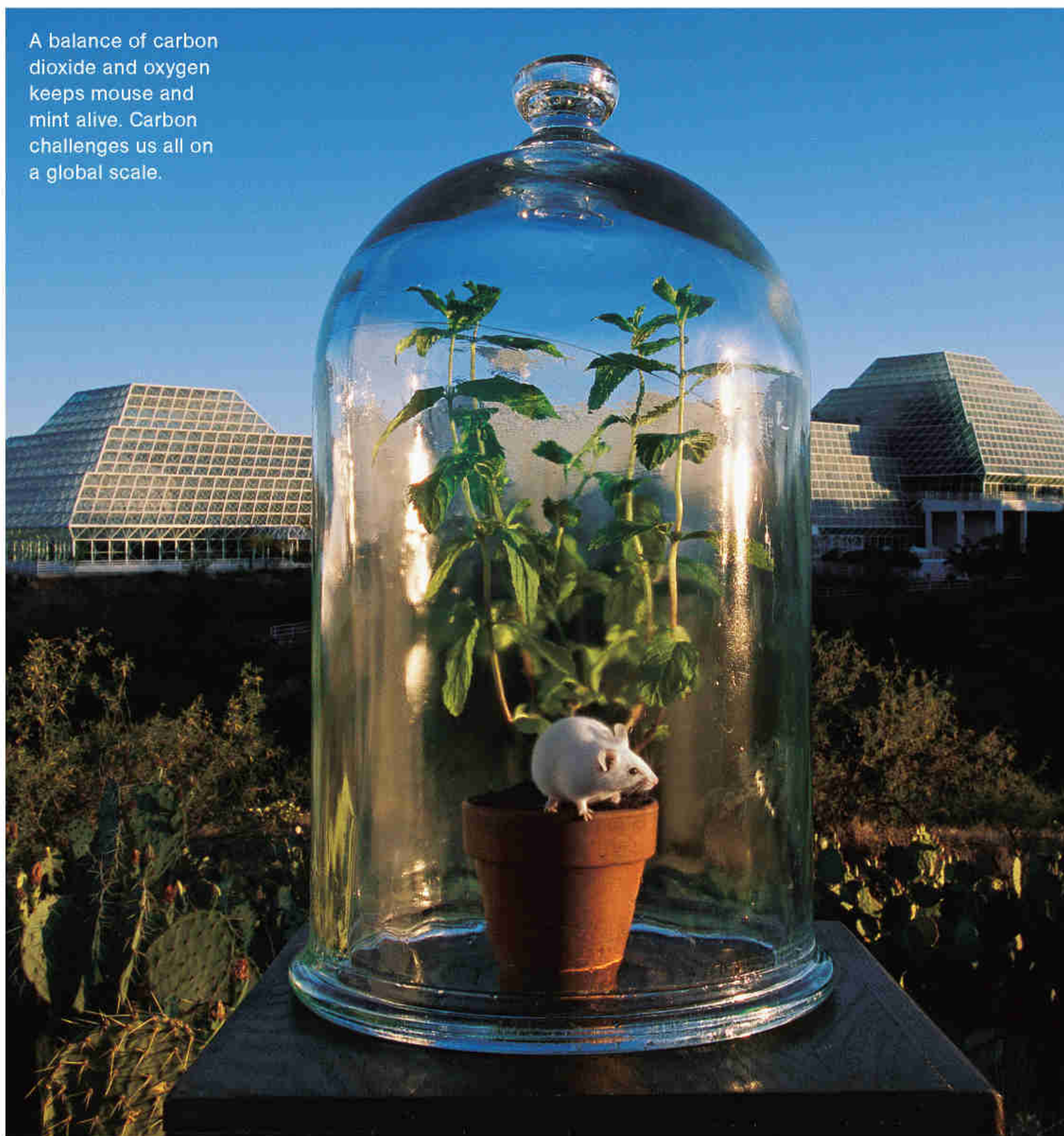
Designed to provoke, engage, and encourage open-minded dialogue among the participants, the Forum will include environmental experts, scientists, economists, business leaders, journalists, writers, educators, and interested consumers who together will examine the state of the planet and share their ideas for the future.

For more information go to aspenenvironment.org.

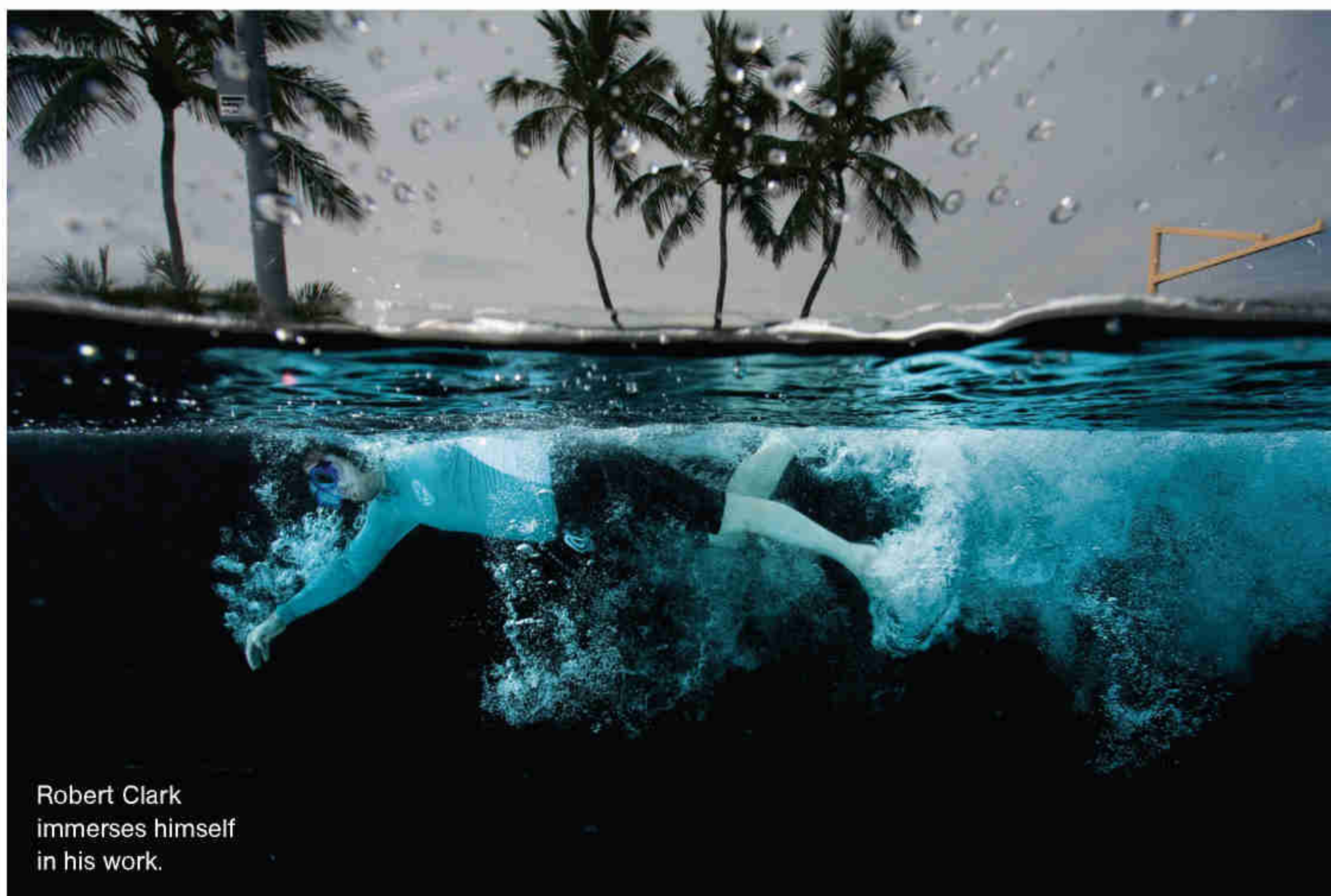
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SPECIAL REPORT Changing Climate Earth's climate is in flux, but according to a new *National Geographic* special issue, it's not too late to do something about it. The publication looks at the changes happening around the world, explains the science, and offers solutions. A pullout section—to stick on your energy-efficient refrigerator—suggests ways to shrink your carbon footprint. The report also points to broader sustainable solutions, such as wind or solar power, that can help meet the world's rising energy needs. *Changing Climate*, available April 1, is for sale on newsstands for \$4.95, or call 1-800-777-2800. For more information, visit ngm.com.



Robert Clark
immerses himself
in his work.

ON ASSIGNMENT Splashy Robert Clark arrived at the Key West, Florida, pool at 9 a.m., though his shoot with Olympic swimmer Gary Hall, Jr. (see pages 84-5), wasn't scheduled until sunset. It took that much time to get ready. Clark's assistant, Christopher Farber, swam competitively in college; he did most of the test-picture swimming. But the photographer also jumped in. "Unfortunately, I don't look quite like Gary Hall," says Clark, who showed this shot to the Olympian. Hall's feedback: "You might want to keep your hips up."



Trillin (center) and interpreter Apu Bandyopadhyay (right) visit a *dera* owner.

ON ASSIGNMENT

Rickshaw Writer

While in Kolkata, India, to write about rickshaws, Calvin Trillin visited the *dera*, or rickshaw garage, of Mohammed Tahir (left). Rather than use rickshaws, Trillin got around mostly in the city's cabs, which are inexpensive but often get snarled in traffic. He did try out the subway, which is supposed to have eased traffic woes, but says, "It's hard to realize that the traffic used to be worse, because it's pretty bad."

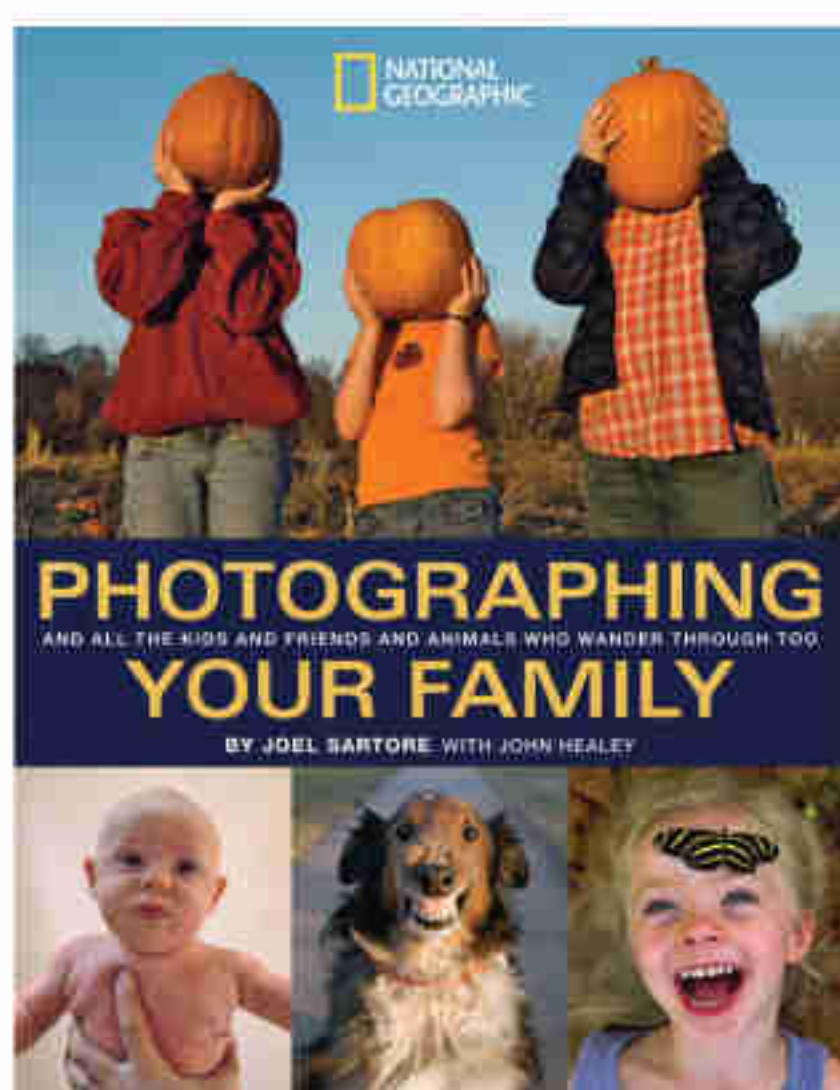


One American will consume this much bread in a lifetime.



Human Footprint Take a shower a day and in 77 years you will have soaped up more than 28,000 times—and sent a lot of water down the drain. Airing April 13 at 9 p.m., the National Geographic Channel's *Human Footprint* shows symbolically just how much average Americans consume. Rows of 28,433 rubber ducks represent the showers; 12,888 oranges, 43,371 soda cans, and 3,796 disposable diapers also star. But rest assured: The show's producers used recycled material and expired food when possible.

NG Books



Photographing Your Family

As longtime *National Geographic* photographer Joel Sartore makes clear in his new book, if there's one thing you should be able to get good pictures of, it's your family. You have the time, the access, and—as long as you can figure out how to get the camera to work—the ability. Sartore offers lessons on lighting, backgrounds, and composition using images of his own family. Whatever you do, he says, don't line the relatives up, order them to smile,

and blind them with the flash. Some of his suggestions:

- Practice photographing sleeping people—until they wake up and get mad.
- Think twice about shooting births and funerals.
- Floors make excellent back-grounds, and standard indoor lightbulbs give great light.
- Children's cooperation can be bought with ice cream.

Photographing Your Family is in bookstores now for \$24.95.

If You Purchased Any Airborne Products You Could be Entitled to Money

A Settlement has been proposed in a class action lawsuit with Airborne Health, Inc. and other persons and entities ("Defendants").

What Is the Lawsuit About?

The lawsuit claims that Defendants made misleading or false statements about Airborne products. This includes, among other things, that Airborne can cure or prevent colds. Defendants deny any wrongdoing or illegal conduct but have agreed to settle the case.

What Airborne Products Are Included?

Airborne Effervescent Health Formula; Airborne On-the-Go; Airborne Power Pixies; Airborne Nighttime; Airborne Jr.; Airborne Gummi; and Airborne Seasonal.

Am I a Member of the Class?

You are a member of the class if you purchased any flavor or formulation of any Airborne Product in the United States or any of its Territories from May 1, 2001 through November 29, 2007.

What Does the Settlement Provide?

A Settlement Fund of \$23.25 million dollars will pay valid claims and attorneys' fees/expenses awarded by the Court. The Defendants will pay separately for other costs.

If valid claims exceed \$23.25 million, Defendants will add \$250,000 to the Fund. If valid claims exceed the Fund, Class Member payments will be reduced proportionally. Any money left in the Fund will be donated to non-profit organization(s).

How Much Money Can I Get Back?

If you have receipt(s), you may seek reimbursement for the receipt amount less sales tax. If you do not

have receipt(s), you may still seek reimbursement for up to six boxes of Airborne products, as explained in the detailed Notice.

The Settlement does not require Airborne to change its advertising. Ongoing governmental inquiries will address such changes, if any. If you stay in the Class, you will not be able to sue Airborne for these claims.

What Are My Options?

- **File a Claim.** You must remain in the Class to file a claim. You will be bound by the Court's rulings, but you can object to or comment on the Settlement. Claim Forms must be signed and postmarked (or submitted online) by **September 15, 2008** by 12 Midnight PST. By remaining in the Class, you will release claims against the Defendants and their Distributors, as outlined in the detailed Notice, available below. **Please read the Release carefully, as it affects your legal rights.**
- **Exclude yourself** and keep your right to sue the Defendants. Your written request for exclusion must be postmarked by **May 12, 2008**.
- **Object or comment on the Settlement and/or appear in Court, only if you remain in the Class.** You may hire your own attorney for these purposes. Your written request must be postmarked by **May 19, 2008**. Your written request to appear in Court must be postmarked by **June 2, 2008**.

Details on how to file a Claim, exclude yourself, object or appear in the case are available at the Web site, address or number listed below.

The Court will decide whether to approve the Settlement at the Fairness Hearing on June 16, 2008 at 10:00 a.m.

This Notice is a Summary only.

To get additional information, including a copy of the detailed Notice and Claim Form or to File Online,

Visit: www.AirborneHealthSettlement.com

Call: 1-888-952-9080

**Or Write: Airborne Class Action Settlement Administrator
PO Box 1897, Faribault, MN 55021-7152**



Scale to Fit Fish scales stood in for sequins on a dress that was “the latest to be worn by women,” according to notes accompanying this photo. The image arrived at the *Geographic* in June 1921 but was not published. It may have been acquired for the magazine’s January 1922 story “Certain Citizens of the Warm Sea,” in which author Louis L. Mowbray noted: “The writer has seen an evening gown made wholly of bonefish scales which was indeed a thing of beauty. The scales were bored and laid on a fabric base like shingles on a roof. The resultant effect was like that of the natural body of the fish.” —Margaret G. Zackowitz

🐡 **Flashback Archive** Find all the photos at ngm.com.

PHOTO: KADEL AND HERBERT, NATIONAL GEOGRAPHIC IMAGE COLLECTION

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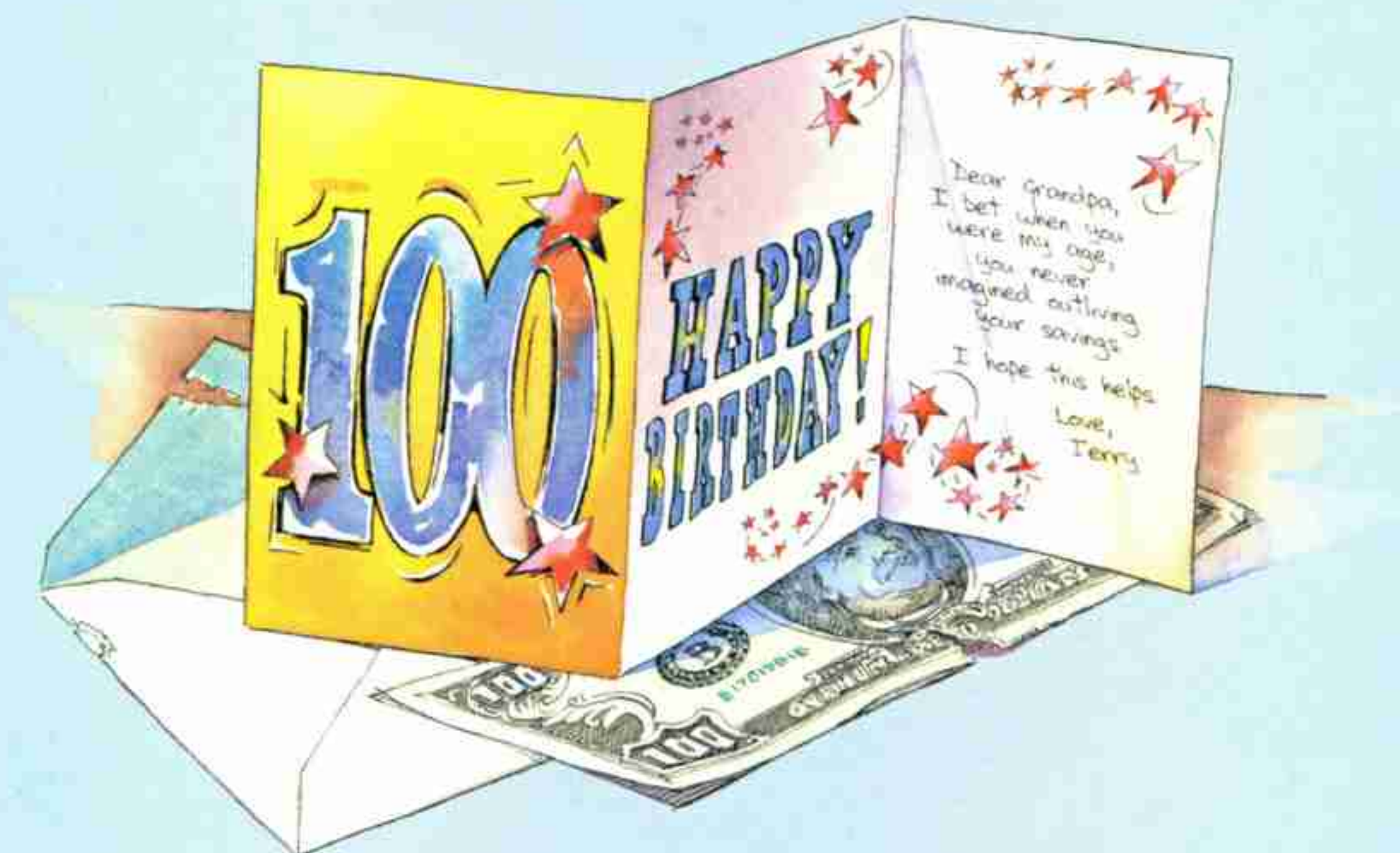
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Allstate has a few ideas on how we can all help:

1. EXAMINE SOCIAL SECURITY.

Americans will not be able to rely solely on Social Security for a comfortable retirement. **The Social Security Administration projects that monthly government checks will cover an increasingly small percentage of the average retirement in the future.** There's debate as to whether Social Security should be repaired or replaced. But what's clear is that we need to reform it now.

2. BOOST RETIREMENT PLAN ENROLLMENT.

Company matches in 401(k) plans are one proven way to increase savings. Other innovative approaches companies can use include **automatic 401(k)**

enrollment, sometimes called opt-out plans; automatic increases in contributions as employees get raises; and encouraging both younger and part-time workers to participate. In one study, just switching to automatic enrollment resulted in a 30% increase in worker participation.

3. REWARD THOSE WHO SAVE.

Ultimately, everyone is responsible for their own retirement. That's why Allstate is a strong supporter of tax laws that help reward people for saving. Tax-advantaged savings vehicles such as **annuities and IRAs are two examples of products that can help America build a strong retirement foundation.**

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